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SARDINE BOATS SAILING TO THE FISHING-GROUNDS.

A SARDINE FISHERMAN'S HOUSE.

THE FRENCH SARDINE INDUSTRY.

By HUGH M. SMITH.

GENERAL IMPORTANCE OF THE INDUSTRY.

Few if any foreign fishery industries are of greater interest or importance to Americans than the sardine industry of France. The wholesome, palatable, and convenient canned sardine is consumed in nearly every community, and the annual importations of French sardines into the United States are worth about $1,000,000, a sum exceeded by the value of but few imported fishery food products. This is perhaps sufficient reason for the presentation of this report; but another consideration is the advantages that may accrue to the fishermen and fish-canners in the United States from a knowledge of the methods pursued in the sardine fishery and canning industry of France.

The sardine is the leading fishery product taken in the waters of France. From official statistics[1] it appears that in 1898 the sardine fishery gave employment to 31,871 fishermen; the number of boats used was 8,164, with a tonnage of 32 863 and valued at 5,934,633 francs; the apparatus employed was worth 7,030,945 francs; the quantity of sardines taken was 53,924,275 kilograms (or 118,633,400 pounds); and the selling price of the fish was 9,204,988 francs (or about $1,840,997).

The information on which this paper is based was obtained by the writer during a visit to Brittany in September and October, 1900, and represents the conditions especially prevailing at and in the vicinity of Concarneau, where most of the time was spent. The fishing and canning methods of the various centers are so much alike in all essential respects that the descriptions here given are applicable in a general way to the entire coast.

THE SARDINE.

There has been and still is considerable uncertainty among the fishing interests in America and Europe regarding the specific relations of the sardine of the Bay of Biscay and the Mediterranean Sea. Some persons have believed that the sardine canned in France is a distinct species, while others have held that the French sardine, like the sardine of New England, is simply the young of some herring-like fish. The term sardine is a general one, applied to various clupeoid fishes, mostly of small size, in different parts of the world, and can not be restricted to any particular fish. Thus, there are the Spanish sardine of the West Indies and Florida; the California sardine, found along the entire west coast of the United States; the Chile sardine; the oil sardine of India; and the sardines of Japan and New Zealand. But the sardine *par excellence* is the French sardine, called also céleren, célan, royan, galice, and cradeau

[1] Statistiques des Pêches Maritimes, Année 1898. Paris. Imprimerie Nationale, 1900.

on various parts of the French coast. The name sardine has reference to the island of Sardinia, in the Mediterranean, about whose shores the fish is abundant.

As early as 1553, Pierre Bélon, a French naturalist, asserted that the sardine is the young of the pilchard; and at present this is the view of nearly all authorities. The pilchard, as is well known, is one of the most important fishes of the southern coast of England, being especially abundant in Cornwall. Young pilchards or "sardines" are found on the Cornish coast, but are apparently not so numerous as in France and are in little demand, as canning is very limited in extent; on the other hand large sardines or pilchards are caught on the French coast, but are much less abundant and less important than the small fish.

In allusion to the small sardine being caught almost wholly by means of bait consisting of fish roe (*rogue*), the French call it *sardine de rogue*, in contradistinction to the large fish which is taken without bait by means of drift nets, and hence called *sardine de dérive*. Modern French writers on the sardine fishery seem averse to acknowledging the specific identity of the sardine and the pilchard; some even fail to explain or suggest the relation between the large and small fishes of the west coast

The Sardine or Pilchard (*Clupea pilchardus*).

of France, but Messrs. Fabre-Domergue and Bietrix, of the French department of fisheries, in a paper[1] on the reproduction of the oceanic sardine, state that they consider the *sardine de dérive* as the adult individual of the species, which toward spring lays pelagic eggs in local waters; the *sardine de rogue*, on the contrary, is the young form, whose age, according to their reasonably exact computations, does not exceed two years.

This fish has been referred to by most American and European systematic writers under the name *Clupea pilchardus* Linnæus. Cuvier, in 1829, described the small fish under the name *Clupea sardina*, which designation is still retained by some writers. In 1803 Lacépède separated the pilchard with several other species from the genus *Clupea*, because of supposed peculiarities of dentition, and referred it to a new genus, *Clupanodon*, which has been revived in a recent American work[2] and made to include the West India sardine, *C. pseudohispanicus* (Poey), and the California sardine, *C. cærulcus* (Girard). Modern European writers on the pilchard (Cunningham, McIntosh, and others) apparently have seen no necessity for taking it out of the genus *Clupea*.

[1] Proceedings of the International Congress of Maritime Fisheries, Sables-d'Olonne, 1896.
[2] The Fishes of North and Middle America, by Jordan & Evermann. Part 1, 1896.

The pilchard is a well-marked species, easily distinguished by prominent radiating lines on the operculum and by large scales, as well as by other features. In general shape it resembles the sea herring (*Clupea harengus* Linnæus), but is less elongated and compressed. The greatest depth of the body is about one-fourth the length, and the length of the head is somewhat greater than the depth of the body. The lower jaw projects slightly; the upper jaw extends to a point opposite the front third of the eye. No teeth are found on the vomer, palate, or tongue, and on the jaws the teeth are either small or absent. The dorsal fin contains 17 or 18 rays, and begins nearer to the end of snout than to the base of tail. The anal fin has 19 to 21 rays. The ventral fins begin under the middle of the dorsal base. There are about 30 scales in a longitudinal series between the gill-opening and the end of the body. The back of the fish is a deep olive green, the sides are silvery, and the belly is white. In the full-grown fish there is a small dark spot in the scapulary region. The normal length attained by the pilchard is 8 or 9 inches; the length of the largest recorded specimen was 14 inches (taken in Cornwall).

The Sea Herring (*Clupea harengus*).

The sardine of the French coast is a handsome little fish, whose beauty is not entirely lost in canning. In the water the back is of a greenish color, but out of the water the upper parts are rich dark-bluish, contrasting strongly with the silvery and white colors of the sides and abdomen. The scales are very easily detached, but their loss does not detract seriously from the appearance of the fish, either when fresh or canned, as the skin is rather thick and has a brilliant uniform silvery color. There are no evident spots on the sides in life, but after the scales are detached a few dark lateral spots may be seen. The back and belly are well rounded, being less compressed than in the young sea herring.

Several American fishes resemble the pilchard, among them the sea herring and the California sardine. The former, which is extensively canned on the coast of Maine, may be distinguished from the pilchard by its more elongate form, by the more posterior origin of the dorsal fin, by the smaller and more numerous scales, by the presence of teeth on the vomer, by the much projecting lower jaw, by the smooth operculum, and by the much compressed abdomen. The California sardine is distinguished from the pilchard in having a more elongate form, fewer dorsal rays, a somewhat longer maxillary, and a series of dark spots along the side.

The flesh is dark-colored, rich, and oily. The fresh sardine, when broiled or grilled, has a delicate flavor and is very palatable. It is improved by the slight salting that it usually receives when intended for immediate consumption. The California sardine resembles the French fish in character of flesh and is a more perfect substitute for it than any other American species.

The range of the sardine or pilchard extends from Sweden to the Madeira Islands. The southern coast of England, the Atlantic coast of France, and the Mediterranean Sea are the chief centers of abundance.

On the coast of Brittany the *sardine de rogue* is found for about nine months of the year, being absent from the inshore waters most of the winter. When the fishing season opens, the fish are reported first about February at Arcachon and other southern points on the west coast, and gradually reach the districts toward the north. During the winter, however, the large fish—some a foot in length—are observed at various places on the coast.

The immature sardines frequent the coast waters throughout the summer and remain in Brittany until late fall. Some years, if the season is mild, they are caught until the first or second week in December; but a storm coming any time in November is likely to drive the fish away and terminate fishing for the season. In 1900 sardine fishing at Concarneau was ended November 5—the same date as in 1899—by a southwest storm, which swept away all the sardines in the bay.

The spawning time on the coasts of England and France is from June to October. Spawning takes place at a considerable distance from the land, and ripe or spawning fish are seldom caught, as fishing is done mostly in the inshore waters. The small fish used for canning purposes on the French coast are never found with ripe eggs or milt, and are now known to be immature fish hatched in the summer and fall of the previous year. The eggs are buoyant, and the average number extruded is reported as 60,000. In the Mediterranean the sardine apparently belongs to a different race, which is smaller than the oceanic form and reaches maturity when under 7 inches in length.

When sardines first arrive they are poor and unsuitable for canning; but as the season advances they improve in quality, and are fatter in September than in June and in December than in September. Their food consists mainly of copepods and other small crustacea. Small fish eggs are also a favorite food. The fondness of the sardine for such eggs plays an important part in the fishery.

The sardines go in schools and swim at or near the surface. As many as 100,000 fish have been taken in one net from one school, but the usual size of the schools is small. They are preyed on by cetaceans and by many fish—on the French coast the mackerel, the haddock, and the dolphin being especially destructive.

Like other free-swimming oceanic fish, the sardine varies in abundance from year to year; but there is no evidence that the extensive fishing is effecting any permanent reduction of the supply. During the years 1887 to 1890 there was an alarming scarcity of sardines on the French coast, and the outlook for the industry was serious, but after four years the fish returned in their former numbers. The history of the sardine fishery shows what extensive operations may be supported annually when the natural conditions permit the fish to spawn unmolested, the spawning-grounds in this case being many miles offshore.

FLEET OF SARDINE BOATS FISHING OFF CONCARNEAU.

SARDINE BOAT FISHING.

THE SARDINE FISHERY.

The sardine fishery of France dates back many years, and even in the early part of the eighteenth century it was an important industry, but it has become much more extensive since the introduction of canning. The building of railroads has also benefited the fishery by providing means of shipping to inland points that part of the catch which can not be disposed of locally. In all of the centers of the west coast essentially the same methods of fishing are followed, with slight local variations. The methods have an important bearing on the quality of the canned sardines, and will therefore be noticed with some detail.

The province of Brittany supports by far the most extensive fisheries and is the center of the canning industry. Here in 1898 were 21,684 sardine fishermen, with 4,611 boats, valued at 3,759,403 francs, and apparatus worth 3,307,643 francs; and here were caught 49,478,365 kilograms of sardines, selling at 7,572,347 francs. The leading center in 1898 was Douarnenez, which was credited with 4,200 fishermen, 710 boats, and over 18,000,000 kilograms of sardines, valued at 2,442,000 francs. Next in importance was Concarneau, with 2,695 fishermen, 490 boats, and 9,163,000 kilograms of sardines, worth 1,719,890 francs. Other important places in Brittany are Audierne, Quimper, Port Louis, Etel, Quiberon, La Turballe, and Le Croisic. Outside of Brittany the fishery is most extensive at Sables-d'Olonne, St. Gilles-sur-Vie, and Arcachon.

On the Mediterranean coast of France sardines are caught at numerous places and by many fishermen, but only in relatively small quantities. The fisheries here in 1898 gave employment to 7,794 men, using 2,861 boats, valued at 1,607,930 francs, and nets valued at 3,386,742 francs; the catch was 2,129,519 kilograms of sardines, valued at 987,738 francs.

BOATS.

All of the boats engaged in the sardine fishery are registered, and have their numbers in large white figures on both sides of the bow, preceded by a letter or letters indicating the town to which they belong (thus, CC for Concarneau). Each boat is taxed about 4 francs yearly by the department of marine and 2 francs by the department of customs. Formerly the boats were smaller, flatter, slower, and less seaworthy. The larger boats, such as are used at Sables-d'Olonne, require rowboats for operating the nets.

Boats are built locally, and cost 1,200 francs when of oak and 1,000 francs when of Norway pine. They do not vary much in size in the different sections. In Concarneau and other parts of Finistère the average dimensions are as follows: Length of keel, 25 feet; length over all, 35 feet; beam, 9 or 10 feet; depth amidships, 6 feet; depth aft, 10 feet; length of foremast, 33 feet; length of mainmast, 36 or 37 feet.

The stern is pointed, the prow is sharp and straight, and the sides flare considerably, so that there is great carrying capacity. There is a broad floor about 2 feet below the rail, and on this platform most of the work is done and most of the fish carried; but when there is a large catch, some of the fish are put below to avoid crushing.

There are two long masts, the foremast raking aft, while the mainmast is nearly vertical. The masts may be lowered if desired. The raising and lowering of the foremast are facilitated by a rope running from its base through a pulley at the head of the mainmast. Each mast carries a large, square, lugger sail, and sometimes a

topsail and a jibsail are employed. The sails are either linen or cotton, the latter being used in summer fishing. Linen sails are tanned brown with catechu and cotton sails are colored with ocher.

The oars are large and heavy, 33 feet long, with a very small, narrow blade, and a square butt about 4 inches in diameter. Owing to the great length of the oar, the butt is large and heavy in order to balance the oar when in use, and stones are sometimes piled on it in rowing. There are four oars to a boat, each used by one man.

NETS.

In parts of Brittany nets were formerly used to surround the schools, and then stones were thrown in to frighten the fish into the meshes. In this way large catches were often made and the market was glutted; but the method came into disrepute and is no longer followed. Fishing is now carried on exclusively with gill nets made of very fine cotton twine. Some of the nets come from Germany, and some are made locally, at Nantes and Douarnenez. Those from Germany are cheaper. The nets are uniformly 45 yards long and 500 meshes deep. A change in depth has taken place within a comparatively few years; formerly they were only 200 to 300 meshes deep. The mesh is necessarily very small, as it is intended to gill the tiny sardines. Its size is determined or designated by stretching the meshes and measuring the distance apart of the first and last knots of a series of five—equivalent to two meshes.

The nets vary in fineness to suit the different runs of sardines, and are of about three standard sizes. The largest mesh, designated 66 mm. (as measured according to foregoing rule), is equal, in America, to 0.66 inch, bar measure, while the smallest size, 40 mm., equals 0.40 inch, bar measure. The intermediate size is 52 mm.

The complement of each boat is 10 nets, representing three sizes of mesh, adapted for small, medium, and large fish. When actively used the nets last only three or four months, but with proper care they often last six months, or even an entire season. When rigged for use they are worth about 100 francs apiece.

The nets are dyed a bright greenish blue, and when suspended from the masts to dry add to the picturesqueness of the fishing boats and the wharf scenes. The dyeing is for the twofold purpose of preserving the nets and rendering them less conspicuous when in the water. The practice of dyeing the nets blue has been in vogue only a short time and appears to have begun shortly after the introduction of cotton nets. Formerly, when linen twine was employed, the nets were stained brown by tannin. The dye substance is an aniline, in the form of a powder, and 50 grams are used on one net. This quantity, with a little alum, is dissolved in enough hot water to thoroughly wet a net. The nets are soaked in the solution and spread out to dry before use. Fishermen are often seen with their hands and wrists stained a uniform blue from handling wet nets. The blue dye is reported to be better than tannin for cotton nets and to render nets less conspicuous. The dyeing is repeated from time to time as the color becomes soaked out.

The nets are kept in position in the water by numerous cork floats and a few sinkers. The corks are 4 inches in diameter and half an inch thick, and about 400 are used with each net. For about 1½ feet below the cork line the net consists of coarser twine of large mesh, to give strength, as, owing to the method of fishing, this part of the net is subjected to great strain. The lower edge of the net for a depth of 3 or 4 inches is also of coarse twine, to support the stone sinkers, two or three sinkers about the size of a man's fist being attached to each net.

SARDINE BOATS AT THE WHARF DISCHARGING THEIR CATCH.

BAIT.

In the fishery for sardines for canning, bait is almost as important as the boats and nets. In no other net fishery in the world is bait so extensively employed and so essential to the success of the industry. The scarcity of bait is always a serious matter in fishing districts, curtailing the catch, reducing the income of the fishermen, and often producing distress among the fisherfolk. It is therefore remarkable that for this indispensable article the French should be absolutely dependent on other countries and that the success of the fishery for sardines should be intimately related to the fisheries for other species in distant lands.

In the early days of the sardine fishery, especially prior to the establishment of canning, small shrimp-like animals, about half an inch in length, were much used as bait. These are one of the natural foods of the sardine and are considered the best bait, but can not be procured in sufficient quantities to meet the demand and are now rarely used. The gathering of this kind of bait was an occupation of the women, who sought the schools in the bays and coves, catching them in large canvas bag-nets. They frequently made their best catches in water up to their necks, when the weather was bad and the water along the shores was thick. The crustacea were heavily salted in barrels and retained until required. The taking of these little creatures appears to have been prohibited many years ago, because of the supposed destruction of fish eggs at the time of catching the shrimps. Although the interdiction is now removed, little effort is made to secure this form of bait.

The bait now in general use is the salted eggs of the cod (*Gadus callarias*), though the eggs of hake, haddock, pollock, cusk, herring, mackerel, and many other fishes are also employed. Cod eggs are not known to possess any properties which make them superior to the eggs of several other species, but owe their prominence to the abundance of cod in regions on which the sardine fishermen depend for their bait supply.

Well-prepared roe has a not unpleasant fishy odor; but the odor is not a matter of any special importance, and the production of any peculiar odor is neither sought nor realized. When the roe becomes old it acquires a rank smell. The sardines are attracted by the sight of the bait rather than by the smell, although it is possible that the strong odor of the old roe used in the early fishing, when the fish are more scattered, may serve to attract the fish. The color of salted roe is a delicate salmon. The ovarian membrane is normally transparent or light; when brown or dark, it is an indication of age or of fresh water (usually rain) having fallen in the barrel.

The annual consumption of roe in France at present is 40,000 to 45,000 barrels, for which the fishermen pay about $300,000. It is reported that in favorable seasons as many as 25,000 barrels of roe have been expended in Concarneau alone.

For at least two centuries cod roe has been imported from Norway, which country has always furnished the greater part of the sardine bait. Other countries which have contributed supplies are Holland, Newfoundland, and the United States. From time to time the French Government has encouraged its own cod fishermen (at St. Pierre and Miquelon; on the Grand Banks; in the waters of Iceland, and in the North Sea) to preserve the roes of cod and other fish, and in 1816 offered a bounty of $4 a barrel for roe made from fish caught by them; but this and other inducements have had little effect on the supply from native sources.

The price of roe has varied greatly from year to year. In the early part of the eighteenth century, bait was bought for 50 cents to $1 a barrel, and throughout that century prices were comparatively low. In the second decade of the last century prices reached their highest point; they were apparently never less than $32, and ranged from that to $60 per barrel. By 1822 the price had fallen as low as $5 or $6, and since then has seldom been as high as $25 or $26, averaging $12 or $15.

The average price for Norwegian roe recently has been about 35 francs ($7) per barrel. In 1900, owing to the failure of the Norwegian cod fishery and the resulting scarcity of roe, the price for Norwegian bait rose to 120 francs ($24) per barrel, or about 7½ cents per pound. The price of American and Newfoundland roe is but little more than half that of the Norwegian. In 1900 the best American roe was selling at $8.60 a barrel and in the previous year at only $4.60.

Mackerel roe, which ranks next to cod in quantity used, brings uniformly 10 to 50 per cent more than the latter.

The sardine fishermen also use peanut meal or flour to mix with the roe, it being much cheaper. It comes in bags holding 75 kilograms, and costs 15 francs a bag. Floating lightly and being quite conspicuous, it attracts the attention of the sardines, which readily devour it. When they gorge themselves, however, the mass swells so as to burst their intestines. The relative quantities of meal and roe used depend on the scarcity of roe and the personal preference of the fishermen. The two articles are often mixed in about equal proportions, but rather more roe than meal is usually employed. In the case of a certain sardine boat in Concarneau, whose operations are elsewhere referred to, the bait consumption one season was 7,500 kilograms of roe and 6,000 kilograms of meal.

The following description[1] of the methods of preparing roe for sardine bait was issued by the French Government in 1817 for the information of the native fishermen, and applies well to the present time:

> The ovary of the cod or of the other fishes of the same family that are fished for on the same bottoms incloses the eggs in a double sac, which is ordinarily thrown into the sea with the refuse. To convert these eggs into rogue, several methods can be pointed out.
>
> The first consists in separating the ovary from the body without tearing the covering, and placing it, with the inclosed eggs, on a plank pierced with holes or in an inclined position, or on a small-meshed net, in order that the drying may ensue equally at all points. When this covering is dry, several ovaries are brought together and placed in a barrel, the bottom of which is spread with salt; and, without pressing them too much, the ovaries are piled one above the other, separated by light layers of salt, until the barrel is entirely full. Then it is closed sufficiently tight to prevent the air from penetrating into it; otherwise there will ensue a fermentation injurious to the quality of the rogue.
>
> Another manner of preparation is to put the eggs into barrels without drying them. The layers of salt and of rogue are put in alternately, as in the preceding case; but as the barrel becomes full the quantity of salt should be increased. Four days suffice for the rogue to sink; the barrel is filled to the top again, and this is continued until the vessel is ready to be closed. To provide for the escape of the brine the precaution is taken to pierce several holes in the lower end of the barrel; by this means the brine escapes and the rogue forms a mass, which keeps in good condition up to the month of June, when the fishermen carry it to Bergen. There the salting is finished by adding a quantity of salt equal to the first; the rogue is put into new barrels, which are also pierced, and these can immediately be delivered to the merchants, who ship them to France. It is said that formerly the Hollanders

[1] Instruction sur la Manière de preparer les Rogues de Morue et de Maquereau employées comme Amorces dans la Pêche de la Sardine.

bought in Norway a certain number of barrels of this rogue, to which they gave this last treatment, and that they sold it afterwards to advantage in barrels of oak wood under the name of rogue of Holland fish. In Norway use is not made of Portuguese or Spanish salt, but of French salt; that of Croisic or of Ile de Ré seems to possess the desirable qualities.

The preparation of the rogue, according to the two processes which have just been mentioned, is susceptible of improvement. It has been improved in Norway, especially since the very much higher price obtained in the markets of France has stimulated the activity of fishermen; for it must not be supposed, because the importation of rogue into Brittany has diminished, that less rogue is manufactured at Loffoden. It has simply found another market in Biscaye and in Galicia; but its importation into Brittany would very soon be resumed if French trade were not promptly supplying our wants in this direction.

The proportion of salt to rogue is as one to four, 25 kilograms of salt sufficing for 100 kilograms of rogue.

The method of improving this substance consists particularly in ridding it of all fatty and mucilaginous parts and in rejecting the envelope of the eggs, over the length of which are spread a number of blood vessels, which render it all the more susceptible of fermentation, since salt has little effect on them. It is important to preserve the eggs from contact with the air, which gives them a yellowish-red tint, especially if the temperature is high. Fine salt is more suitable than coarse salt, and marine salt should be preferred to mineral salt. Cod eggs derived from summer fishing require more salt than those from the winter fishing, decomposition being less active in winter than in summer. It is necessary to exclude from salting all rogue of fish too ripe; the rogue has not the necessary consistency when the eggs are about to be extruded. It is what the Norwegians call *blöde rayn*, soft rogue.

The barrel should be hermetically closed except a hole in each end, one to give passage to the brine, the other to let the gas freely escape. There should be no space between the upper end of the barrel and the rogue, which can easily occur if the barrel is closed only several days after it is filled. As much as the arrangement of the building permits, the barrels should be sheltered from dampness.

By taking these precautions one is sure to prepare rogue superior to that which the Norwegians put on the market, especially if the quantity of salt employed has been calculated, according to its more or less penetrating qualities, as new salt or old salt.

In the respective interests of the cod and sardine fishermen, it would perhaps be well to make use only of barrels of a uniform gage; but this is a matter which could be settled later.

Finally, the French fishermen ought to prepare the rogue with all possible care. It is the best means of assuring sale, of obtaining preference in the markets of Brittany, and of having no longer to fear there foreign competition.

In the ports in which mackerel fishing is conducted the rogue of this fish can be prepared in the same manner as that of the cod, and is in fact so prepared in some of them. In applying to the preparation of the eggs of the mackerel the simple and easy methods indicated for the eggs of the cod, both will be improved in the same degree; they can very soon supply the place of each other and maintain the equilibrium between the needs and resources of each year. The union of their respective products will then free the sardine fishery from the tribute which it has paid to foreigners, a tribute which they themselves are no doubt astonished at receiving for so long a time.

In an article on "The Sardine Industry in Vendée"[1] Dr. Marcel Baudouin has the following references to bait:

The rogue or résure is that which serves as bait for taking the sardine on the coast of the ocean, while in the Mediterranean no use is made of it. The rogues are called natural or artificial. The natural rogue, the most prized, is of a very high price.

Since it is necessary to employ large quantities, it can easily be conceived that an attempt would be made to substitute other substances; whence the invention of artificial rogues, which are manufactured especially in Brittany. In Vendée these artificial rogues are little employed. Some fishermen sometimes prefer to them bait yet more simple and common, bran incompletely sifted, the product of the flour mill, of which the cost price is almost nothing (it has been employed at Saint-Gilles recently),

[1] Revue des Sciences Naturelles de l'Ouest, 1893.

or else a sort of special bait called gueldre, a mixture of the fry of fish and little crustaceans, especially prawn and shrimps, broken and pounded. Forbidden in 1726 by a declaration of the king, the use of gueldre was allowed in 1853, then forbidden a second time. Now it is employed again, not only at Croisic and at Turballe, but in Vendée—at Noirmoutiers, for example—where it has procured good fishing. There, as well as elsewhere, it is said to spoil the fish by facilitating decomposition. The manufacturers reluctantly buy sardines caught with this bait.

A number of artificial rogues have been tried in Vendée. We will point out from memory the principal ones which, successively, have been used in commerce: (1) The artificial rogue called "de Douarnenez," prepared by Messrs. Morvan and Delasalle. (2) The same rogue, modified by Mr. Morvan in 1876, which contains pickled meal and a small quantity of natural Norwegian rogue; this is the "farinaceous mixture of Morvan"; it is no longer manufactured; in 1877 a barrel of 130 kilograms of this rogue was worth 25 francs, while a barrel of good natural rogue was worth 40 francs at least. (3) The "heterogeneous rogue" of Mr. Ispa (of Douarnenez) is composed of cakes formed of oleaginous grains (sesame, arachide) diluted with water and a quarter of Norwegian rogue. (4) Caillo, senior, about 1818, made a trial of artificial rogue, composed of boned sardines, pounded and reduced to a paste; he used the flesh of all fish except of those called fat fish. (5) Caillo, junior, reports that a long time ago a pharmacist of Leon d'Angers prepared and sold as rogue grains of linseed or rape seed.

While these artificial rogues may still be occasionally used in Vendée, recourse is usually had to the two natural and well-known rogues. At the Sables, on the Isle of Yeu, among others, the rogue of Norway or of Bergen is employed (rogue made with the eggs of salted cod, stockfish) to cause the fish to come to the surface of the sea at the beginning of the fishing. The rogue made with the eggs of the mackerel serves to keep the fish on the water. This last costs 70 francs a barrel of 130 kilograms; the Bergen rogue, very much in use on the Vendéen coast, is not worth more than 55 to 60 francs.

FISHING SEASON, GROUNDS, AND METHODS.

Sardines are caught in greater or less numbers throughout the year. On the west coast, however, the fishing season opens in February and continues to November, rarely extending into December. In Brittany the fishing begins rather later and continues longer than at points farther south on the Bay of Biscay. Fishing in the canning district is continued as late as practicable, usually as long as the fish remain in abundance, as their condition at that time is good. In the Mediterranean sardines are caught during every month of the year.

The sardine fishery is emphatically a shore fishery, and most of it is done within a very short distance of the home ports. This permits the use of smaller and less expensive boats than would otherwise be required, and insures the landing of the fish a short time after capture.

The early fishing for the sardine de dérive is mostly within 1 or 2 miles of the shore and rarely beyond 5 or 6 miles. In the summer and fall fishing with bait, the boats may go 10 miles to sea, but the largest part of the catch is taken within 3 or 4 miles of shore, and a very considerable proportion close inshore in the bays.

The fishing in the early part of the season—that is, in March, April, and May—is done mostly with old nets and is conducted only at night. About 20 nets are used by each boat. These are tied together and submerged about 1 yard, the corks being attached in bunches of four or five at intervals of 2 yards. While the boats are lying near by under a small aft sail and the men sleeping, the nets are allowed to drift. No bait is used. The fish thus caught are not fat and not used for canning, but are salted or sold for immediate consumption.

The regular fishing is carried on only by day. The boats start for the fishing-grounds early in the morning (2 to 4 o'clock), so as to be there when day breaks;

A PART OF THE SARDINE FLEET AT THE DOCK IN CONCARNEAU.

they may also have to leave earlier if the tide would otherwise beach them. The best fishing is in the early morning, and the boats are often back to port by 9 or 10 o'clock with full fares.

When waiting on the fishing-grounds (at night, early in the morning, or at any other time) the fishermen place one of the long oars obliquely upward and backward from the bottom of the boat to the rear mast (where it is fastened), and over this they spread a sail. Under this shelter they sleep or rest.

When a boat arrives on the fishing-grounds the rear mast is taken down and the boat is headed toward the wind. If fish are present a net is shot and slowly towed by means of a short line attached to the cork line and fastened in the stern of the boat. When there is no wind, or when the wind is from an unfavorable quarter with reference to the water currents, the sails are lowered and the crew row the boat. In the sardine fishery at Sables d'Olonne, where large boats are used, the nets are not towed therefrom, but are pulled by means of rowboats.

Bait is always used in the day fishing, being necessary in order to attract the fish to the vicinity of the boats and into the nets. The casting of the bait, on the proper use of which a great deal of the success of fishing depends, is always done by the master or "patron," who stands in the stern of the boat on a little platform and uses the flour and roe as required. When the fish have come toward the surface and are on one side or the other of the net his object is to cast the bait in such a way that they will rush against the net and become gilled.

Considerable skill and experience are of course necessary in managing the net and in having it hang properly in the water and not become folded or wavy owing to currents or tide. Unless the net is straight or gently curved, the fish will see and avoid it. When a net contains fish and is ready for hauling, it is taken in the boat and the fish are removed from the meshes by gently shaking the net or by hand. The fish are put in a compartment in the bottom of the boat. When large catches are made other receptacles are provided.

In summer fishing, when sardines are abundant, the fishermen often let one net go adrift when it is full of fish, trusting to pick it up later, and put out another net. Indeed, a boat may have fish in three nets at one time, though this is rarely the case.

The sardines are often found in a more or less compact body, and the boats will be concentrated in a comparatively small area, at times so close together that the operation of the nets would seem almost impossible and the chance of catching fish very improbable. The entire fleet of a given port—consisting of several hundred boats—may be at work on one school and fishing literally en masse instead of individually. This is shown in a measure in the upper figure of plate 2.

No ice or other preservative is used on the fish, which are landed a short time after gilling. The fish reach port in good condition, and are often at the canneries within one or two hours after capture. Should the failure or unfavorable direction of the wind threaten to delay the arrival of the boats, and hence impair the quality of the fish, the crews row leisurely back to port.

Soon after reaching port the nets are spread for drying, being hauled to the top of the masts and suspended between them for this purpose. When all the fleet has arrived and the nets are spread, the view of the maze of blue nets, sails, and masts is most interesting and unique.

WHARF SCENES.

When the fishing boats begin to arrive, the wharves, which have practically been deserted, assume a very busy and animated appearance, and as the arrivals increase in number the bustle among the different classes of people becomes intense, although good nature and good order prevail. The foreign visitor here witnesses some exceedingly interesting and picturesque fishing scenes—thousands of fishermen in their coarse blouses and flat cloth caps, with trousers rolled up and their feet bare or in the huge wooden shoes of the country, unloading their fish and carrying them

Washing Sardines on the Beach.

to the canneries; hundreds of women and girls in short dark skirts, white caps and collars, and wooden shoes, negotiating for sardines, receiving the fish from the fishermen, and dispatching them to the canneries; sardine boats, either rowed or sailed, entering the harbor in groups or singly and coming up to the already congested docks; fish wagons going to and from the factories, and a mixed crowd of merchants, sight-seers, artists, and idlers. The commingled noise of waves, boats, wagons, and tongues is underlain by the incessant rattle of wooden shoes on the stony pavements.

At Concarneau and other places the sardine canners have on the water front

small one-room wooden houses which serve as their headquarters for the purchase of fish. To some of these cabins a telephone wire runs from the factory, so that instructions as to prices and information regarding the quantity of fish landed may be mutually communicated.

The cannery managers, having determined on the approximate prices they will pay for the different sizes of fish, send their purchasing women to the wharf as the boats come in and the bargains are then made. Sometimes the fishermen hold out for better prices and animated discussions ensue.

On arriving at the wharves the fishermen at once begin to discharge their catch. The fish are counted by hand into wicker baskets with round bottoms and sides, each

A Sardine Fisherman bringing Fish ashore in Baskets.

basket having 200 fish (plus 5 per cent for possible imperfect fish). When the tide is low some men remain in the boats and count the fish into baskets, while others haul the baskets to the wharf by ropes and carry them to the shore. The baskets could hold three to five times as many sardines as are put in them, but it is the desire not to crowd the fish. If sardines of different sizes have been caught, it is necessary to sort them into separate baskets; as a matter of fact, however, the nets do the sorting, as each kind of mesh takes fish of a rather uniform size.

Before the sardines pass into the hands of the canner, the fishermen take baskets

of fish and move them rapidly up and down in the water in order to remove the dirt and loose scales from the fish and make them look bright. Many scales come off, and the shores of the harbor are lined with them after a day's fishing. The water about the shores is usually quite foul, and the rinsing of the fish therein seems very objectionable.

The fish are then taken by the fisherman to the agent of the cannery to which the cargo has previously been sold, and the contents of each basket are poured into a flat box or basket. If a cannery is conveniently located the fishermen may carry the fish directly thereto; but as a rule the fish are taken to the factory in wagons, the trays being carefully packed so that no pressure comes on the fish. From the time the sardines are first caught everything that will bruise, mash, or otherwise impair the soundness of the fish is carefully avoided. The method of discharging the catch in small lots insures the arrival of the fish at the cannery in similar quantities and obviates the formation of large piles in the cutting room, as the cutters are in ample numbers promptly to dispose of the fish as brought in.

PRICES RECEIVED FOR SARDINES, ETC.

The prices received by the fishermen are regulated by the factory operators, and depend on the supply, the size and quality of the fish, the weather, and other considerations. The fish of each boat are virtually sold at auction, only there is as a rule no counter bidding, the prices offered by one or two factories being adopted by the others and accepted by the fishermen. If a fisherman is not satisfied with the price offered by one factory, he is at liberty to seek a higher price elsewhere. Some boats always sell their catch to the same factory, and all of them, to a greater or less extent, deal with particular factories.

The maximum price which factory operators can profitably pay for sardines is 25 francs ($5) per 1,000 fish. The dealers in fresh sardines can pay as much as 35 francs per 1,000. At times the demand for sardines to be sold fresh (*au vert*) tends to keep up the prices; but this use is limited and does not interfere greatly with the cannery demands.

The following are the average prices for sardines at Concarneau in 1900, and about the same prices prevailed in other parts of the coast:

Size of nets in which caught.	Price per 1,000 fish.
	Francs.
60 millimeters	17 to 18
52 millimeters	7 to 9
40 millimeters	2½ to 5

Women represent the factories as purchasing agents. They are given considerable discretion by their employers and are very sharp in making bargains. The price agreed on is for the entire cargo. Payments are not made in money, but in tokens or tickets which are redeemed weekly. As the fishermen deliver their fish, two baskets full at a time, to the agents of the canneries, they receive a metal tag or token with the name of the buyer on it. When all the fish are landed the metal

pieces are counted and surrendered and a claim check is issued in their place. At the end of each week the master or the owner of the boat (often the same person) goes to the factory, receives the money due, and apportions the earnings of the crew.

The boat, nets, equipment, and bait usually belong to a non-fisherman (who may own a number of boats). The men of the crew furnish their own food, fuel, and clothing. The owner is entitled to half of the sales of fish, and the remainder goes to the crew in the following proportions: There being 6 men in the crew, 4 of them get equal parts, the captain or patron receives the share of one man plus 10 per cent, and the cook half a share. Dividing the proceeds into 22 parts, the owner is entitled to 11 parts, 4 members of the crew to 8 parts, the master to 2 parts, and the cook to 1 part; the share of the master being increased by 10 per cent of 2 parts and that of each member of the crew diminished by 2½ per cent.

At the end of the season the boat owners usually give to each master a quarter of a share ("quart de lot") as a bonus, if the crew have been selected and engaged for the next year's fishing. In this way it is possible for the owners and the masters to select the best men. During the winter, say in January, the crew will report, and each man will receive, as a kind of bonus, about 5 francs and perhaps a loan of money. Advances are repaid in fish or cash after the season opens.

From the time the men begin to fish until the close of the season, they pay to the government 1.10 francs per month, in consideration of which they are pensioned on attaining the age of 50, provided they have served 300 months on sea duty (either in fishing or in any other maritime occupation). They also pay 1.50 francs per month as premium on an insurance fund which the government allows for injury due to the vicissitudes of sea life. In case of death, the family of the fisherman receives an annual pension depending on the size of family and on the age and length of sea service of the deceased, the minimum sum being 300 francs; naval service increases the pension.

DETAILED FISHING RECORDS.

The average stock per boat in a given season varies greatly on different parts of the French coast, depending on various local causes besides the abundance of fish, such as weather, bait supply, local demand, shipping facilities, energy with which fishing is prosecuted, and other evident factors. The boats fishing out of Brittany ports have a larger average yield than those of other ports of the west coast; and those in the Mediterranean have by far the smallest stocks. Thus, in 1898, the average catch per boat was about 10,700 kilograms of sardines in Brittany, 3,300 kilograms in the southern part of the Bay of Biscay, and only 745 kilograms in the Mediterranean.

Considering the record for 1899 of a certain boat in Concarneau which fished regularly, it appears that the aggregate stock was 4,400 francs, of which the crew of 5 men and a boy received 2,200 francs in the proportions elsewhere mentioned. The owner of the boat had the following expenses to meet out of his half of the proceeds: Twenty-five barrels of bait, at 35 francs; 2 new nets, at 100 francs; 40 bags of peanut flour, at 15 francs; and miscellaneous items, bringing the total to 1,725 francs, leaving a net profit of 475 francs.

Some idea of the energy with which the sardine fishery is pursued at times may be gained from the following outline of one day's fishing operations at 15 centers on the coast of Brittany. The data are compiled from a local newspaper (La Depeche

de Lorient), and relate to September 17, 1900, for some of the places and September 18 for others. The number of boats fishing was about 1,500, the approximate total catch was at least 17,000,000 sardines, having a value of 200,000 francs, or $40,000.

Audierne, September 18: Number of boats going out, 200; average number of fish per boat, 6,000 to 8,000; average price per thousand, 13 francs; size of sardines, 12 to 14 to the quarter can (*quart*).

Concarneau, September 17: Number of boats going out, 500; average number of fish per boat, 2,000; sold fresh (*au vert*), 30,000; sold for frying (*friture*), 970,000; average price per thousand, 18 francs; highest price, 24 francs; lowest price, 2.50 francs.

Croisic, September 18: Number of boats going out, 2, which have caught 6,000 to 7,000 sardines; highest price per thousand, 28 francs; lowest price, 26 francs.

Douarnenez, September 18: Number of boats going out, some hundreds; average number of fish per boat, 45,000; average price, 14 francs; size of sardines, 8 to 17 to the "quart."

Etel, September 17: Boats not going out because of bad weather. *Sept. 18:* No fishing. The boats going out late have been unable to fish on account of a calm and have not returned at evening.

Gavres, September 17: Number of boats going out, 86; average number of fish per boat, 9,000; number of fish to the "quart," 10 to 12; average price per thousand, 4.50 francs; highest price, 7 francs; lowest price, 3 francs. Some boats have an average of 18,000 to 20,000 fish.

Guilvinec, September 17: Number of boats going out, 20; average catch per boat, 15,000 to 20,000; number of fish to the "quart," 14 to 16; average price per thousand, 4 francs; highest price, 5 francs; lowest price, 3 francs. Some boats have an average of 25,000 fish.

Ile Tudy, September 17: Number of boats going out, 35; average number of fish per boat, 15,000; number of fish for frying, 535,000; highest price per thousand, 7 francs; lowest price, 2 francs. Some boats have an average of 20,000 fish.

Lannion, September 18: Number of boats going out, 67; average number of fish per boat, 1,100; average price per thousand, 9 francs; highest price, 10 francs; lowest price, 8 francs. Some boats have an average of 5,000 fish.

Loctudy, September 18: Number of boats going out, 35; average number of fish per boat, 15,000; average price, 6 francs.

Palais, September 17: Number of boats going out, 75; average catch per boat, 3,000; sold fresh, 50,000; sold for frying, 165,000; average price per thousand, 15 francs; highest price, 16 francs. Some boats have an average of 6,000 fish.

Penmarch, September 18: Number of boats going out, 45; average catch per boat, 10,000; average price, 4.50 francs; size of sardines, 12 to 18 to the "quart."

Port Louis, September 18: Number of boats going out, 55; average number of fish per boat, 6,000 small; 10 boats with 4,000 large; average price, small, 5 francs; large, 18 to 22 francs; sizes of fish, 7 to 8 and 16 to 20 to the "quart."

Saint Guénolé, September 17: Number of boats going out, 100; average catch per boat, 15,000; number of fish sold for frying, 15,000; average price at midday, 4 francs; highest price, 6 francs; lowest price, 2.50 francs. Some boats have an average of 20,000 to 25,000 fish.

Sauzon, September 17: Number of boats going out, 84; average catch per boat, 10,000; number of fish to the "quart," 7 or 8; average price per thousand, 15 francs; highest, 16 francs; lowest, 14 francs. Some boats have an average of 13,000.

The following similar record is for several of the foregoing places and some additional ones on September 22 and 23, 1900:

Croisic, September 23: Number of boats going out, 30; average catch per boat, 2,000; average price per thousand, 24 francs; highest price, 28 francs; lowest price, 20 francs. Some boats have an average of 5,000 fish.

L'Herbaudière, September 22: Number of boats going out, 25; average catch per boat, some hundreds; number of fish sold fresh, 30,000; uniform price per thousand, 12 francs. Some boats have an average of 6,000 to 7,000 fish.

Lannion, September 22: Number of boats going out, 65; average number of fish per boat, 1,300; average price per thousand, 9 francs; highest price, 10 francs; lowest price, 8 francs. Some boats have an average of 6,500 fish.

La-Turballe, September 22: Number of boats going out, 60; average catch per boat, 3,000; number of fish to the "quart," 9 to 10; sold fresh, 120,000; sold for frying, 80,000; average price per thousand, 18 francs; highest price, 23 francs; lowest price, 15 francs. Some boats have an average of 4,000 and 5,000.

Les Sables, September 22: Number of boats going out, 150; average catch per boat, 6,000; number of fish to the "quart," 14 to 16; average price per thousand, 4 francs; highest price, 6 francs; lowest price, 2.50 francs. Some boats have an average of 17,000 fish.

Lomener, September 22: Number of boats going out, 40; average catch per boat, 7,000; number of fish to the "quart," 15 to 20; uniform price per thousand, 4 francs. Some boats have an average of 10,000 sardines.

Port Louis, September 23: Number of boats going out, 86; average catch per boat, 8,000; number of fish to the "quart," 10 to 12; average price per thousand, 3 francs.

SARDINE BOATS ON THE SHORE, CONCARNEAU.

A GLIMPSE OF THE WATER FRONT, CONCARNEAU

THE CANNING INDUSTRY.

THE FACTORIES.

The construction of the first sardine-canning establishments dates from about 1845, since which time the growth of the business has been almost uninterrupted. The factories gave to the sardine fishery a great impetus, and to-day are the chief supporters of the very extensive fishing operations in the Bay of Biscay.

The factories are generally large stone structures surrounded by a stone wall and inclosing a courtyard. They cost from 30,000 to 75,000 francs or more to build and equip. Their capacity varies greatly. Some are able to utilize upward of a quarter of a million fish daily. The yearly output of individual establishments is from 300,000 to 4,000,000 or 5,000,000 boxes. They pay no special license tax, but have the same taxes as other manufacturing establishments, based on number of employees and size of plant. The output is not taxed.

In no line of the business is there any standard to be followed, except what the trade demands and the interests of the canners dictate. There is no government or other official inspection of the canned products.

The sardine canners, not unnaturally, are averse to having strangers enter their works and are circumspect in granting permission to do so. Almost every canner has some slight peculiarity in method of preparation which he thinks advantageous and worth being kept to himself. As the factories are surrounded usually by high stone walls, and entrance is only through a guarded gate, a stranger might remain in some of the fishing villages for a long time without being able, from personal inspection, to learn anything about the canning methods.

No complete statistics for the canning industry are available, but it may be stated that over 100 factories are operated, and not less than 15,000 persons, mostly women and girls, are employed therein. Concarneau and Douarnenez have more factories than any other localities, the number operated in 1900 being 29 and 25, respectively. A large number of the canning establishments are owned or leased by companies having headquarters at Bordeaux and Nantes.

CANNING PROCESSES AND MATERIALS.

When the fish are taken to the factory they are spread on large tables and sprinkled with a little salt. The women who remove the heads and viscera either stand or sit, and perform their work with great rapidity. They hold the fish in the left hand and with the right hand press the knife into the back and side of the head of the fish, using the right thumb for a counter pressure. The head is pulled or torn off, rather than cut, and the esophagus, stomach, and most of the intestines go with it. The body drops into one basket, the refuse parts into another. The refuse is disposed of to farmers for fertilizing their fields.

Immediately after evisceration the fish are sorted by size into large tubs (half oil barrels holding 250 liters) containing a brine strong enough to float a potato. Here they are left for half an hour to an hour, depending on their size, quality, and the condition of the weather. They are then placed in small wicker baskets and taken to the yard, where they are washed in either fresh or salt water (salt preferred) while in the baskets, each basket being put through two waters. This washing, which takes but a few seconds, removes from the fish any undissolved salt, loose scales, and dirt.

Drying, which is the next step, is preferably done in the open air, and a large part of the product is so treated. For open-air drying the fish are arranged by hand, one by one, in wire baskets or trays holding about 150 fish of medium size, placed on wooden frames or flakes. The baskets are 16 or 18 inches long, 9 inches wide, and 3½ inches deep; are made of coarse wire with a polygonal mesh two-thirds or three-fourths inch in diameter, and have a long bridle-like wire handle on each side by which they are suspended on the flakes, each bridle having at its middle a loop or ring which interlocks with its fellow. The distinctive feature of this wire tray is its division into about 7 crosswise compartments, V-shaped in section, the spaces being pointed at the bottom and open above. The divisions are of coarse wire, and one side of the V forms a wider angle with the basket bottom than the

Beheading and Eviscerating Sardines.

other. Against the more oblique sides the sardines are placed in regular rows, with their tails upward, so as to promote the escape of water from the abdominal cavity. By means of the loop in the handle some of the baskets are hung on the frames, somewhat above the head; others are rested on lower frames. Wooden baskets or trays are used in some places.

The sardines remain out for a variable time, depending on their size, the state of the atmosphere, etc. The usual time in favorable weather is one hour.

In damp, foggy, or rainy weather (especially in autumn), the sardines must be dried indoors by artificial heat, and drying ensues much sooner than in the open air. Some factories, not being provided with driers, are unable to operate in such weather. In most of the factories—especially those more recently constructed—artificial heat is supplied in a special drying chamber by means of steam pipes; but in some of the

older canneries the wire baskets are suspended from a wire lattice under which are small charcoal furnaces.

From the drying flakes the fish are taken in the same wire baskets to the cooking room and immersed in boiling oil, in open vats of various sizes and construction. As the fish are quite dry, much of the oil is taken up in cooking and has to be replaced from time to time by fresh oil. The immersion in oil usually lasts about two minutes, but depends on the size of the fish and is best gaged by experience. When the caudal fin will break easily, the fish are said to be cooked enough. The baskets are then removed to a table or platform with an inclined metal top, where the surplus oil is allowed to drain from the fish. After a few minutes the baskets are taken to the packing room, where they are hung on wooden frames over metal-top tables for further draining and cooling. The oil which drips off here is in some places used in soap-making.

The sardine manufacturers employ two kinds of oil in their canning operations—olive oil and arachide or peanut oil; and small quantities of sesame oil have at times been used. While it is reported that the manufacturers knowingly handle only the oils named, it is understood that cottonseed oil, being tasteless and cheap, is used by the French oil-dealers for adulterating both olive and peanut oil. Information on this subject is naturally difficult to obtain; but the testimony of several oil-manufacturers and dealers clearly indicates the existence of the practice. It is interesting to note, in this connection, that during the fiscal year 1899 the United States exported to France nearly 17,000,000 gallons of cotton-seed oil, having a value of $4,000,000.

French olive oil is used with the best quality of canned sardines. Fish packed in it will remain in good condition ten years or longer, and are reported to be better the second year after packing than earlier. The cost of olive oil to the canners is from 175 to 300 francs ($35 to $60) per 100 kilograms.

Arachide oil is extensively employed. It is made in Bordeaux, Fécamp, and Marseilles from peanuts imported from India, Senegal and other parts of Africa, and other countries. It comes in three grades and costs 65 to 95 francs per 100 kilograms, the best quality being worth less than one-third that of the best olive oil. The mass remaining after the expression of the oil from the peanuts is made into cakes and used as food for cattle. The cakes are ground into flour and employed as bait in the sardine fishery.

Peanut oil is largely used to meet the American demand for a low-priced sardine. Most of the cheaper French sardines exported to America are packed in peanut oil, which is practically tasteless.

A canner may fry his sardines in peanut oil and fill the cans with olive oil, or vice versa; or one oil, with or without the admixture of cotton-seed oil, may be used throughout the process.

The following account of the utilization of peanuts in France is quoted from the Philadelphia Manufacturer:

> Americans have come to look upon the peanut chiefly as an article of food, associating it with circuses and country fairs. Its employment for food purposes is, however, one of the least important of its uses. Although Europeans seldom eat the nuts, Marseilles is the peanut center of the world. In 1899 that city imported 61,241 tons of unshelled and 9,579 tons of shelled peanuts, and that was not an unusual year. Bordeaux also uses large quantities every year, but the first-named city stands in Europe at the head of the production of vegetable oils from oleaginous seeds. The chief sources of

the city's peanut supply are Bombay, Mozambique, and Senegal, although large quantities are received from other places.

In the Marseilles crushing mills for handling the peanuts, the shells are broken by means of toothed rollers and the kernels separated by a system of winnowing machines, such as are used in flour mills. The inside red skin is then removed by revolving sieves and air blasts, and the kernels are ground, after which they are ready to be pressed. The pressing takes place in the same manner in which other oleaginous seeds are pressed, the meal being enveloped in strong fibrous mats and subjected to hydraulic pressure. The resulting cake is then reground, the oil remaining in the meal secured as in the first instance. The oil is graded according to first, second, or third extraction. This oil, after being clarified by filtration and the admixture of fuller's earth, is put on the market and used as an illuminant, and more extensively as an adulterant in olive oil, in which latter field its chief competitor is cottonseed oil.

The cake left is sometimes chemically treated to secure the oil that may have escaped the presses, but whether thus treated or not, it is valuable as a food for cattle. The husks are sometimes used for fuel, and they have some value as fodder, although goats are about the only animals that will eat them when not mixed with the peanut cake.

Sesame oil comes from Egypt, and costs about 80 francs per 100 kilograms.

There are various other ingredients with which or in which the sardines are packed to give them flavor or piquancy. Some of the very best goods are prepared with melted butter of good quality instead of oil; these are mostly for special French trade. Tomato sauce, pickles, and truffles are also used. With all of these the sardines are packed precisely as when oil is employed and in cans of the same sizes. Only relatively small quantities of such goods are prepared.

When the fish reach the packing room, the women who had been cutting will probably have finished that task and are seated at a table ready to take up the packing of the sardines in tin boxes; they carefully place the fish in the cans, and then pass them along to another set of women who fill the boxes with oil from a faucet or with other materials used with the sardines—tomato sauce, mustard, truffles, etc.

In some countries (United States) the trade demands that the blue back of the sardines be uppermost when the box is opened; while for other countries (France, Belgium) the white belly should be uppermost. The position of the fish when the top of the can is removed by the consumer is reversed in packing, as what is the bottom of the can from the packers' standpoint is in reality the top.

With most of the oil sardines a small quantity of spices is used in order to impart a flavor. The usual ingredients for each can are 1 or 2 cloves, quarter or half of a laurel leaf, and a small piece of thyme; these are put in the can before the fish, so that they will be on top when the can is opened. The fresh leaves of tarragon (*estragon*) are sometimes used.

Sardines are packed in tin boxes of a large variety of sizes and shapes, some of which are well known to the American public, while others do not enter into the general trade here. Among the kinds which have received special designations are the "quart bas," "quart haut," "demi," "huitième," and "triple." The "quart" can is the standard. It ordinarily contains 12 to 14 fish, but sometimes as many as 20 and sometimes only 6 or 8. The "demi" is twice as large as the "quart," and the "huitième" is only half as large; while the "triple" contains 12 times as much as the "quart." Lozenge-shaped and boat-shaped cans (which are protected by patent) are also employed by a few companies; and some factories put up fish in glass vessels. The standard wooden cases in which the cans are packed and sent to market contain 100 "quarts," 200 "huitièmes," 50 "demis," etc.

YARD OF A CANNERY. WOMEN CUTTERS AWAITING THE ARRIVAL OF SARDINES.

FRYING SARDINES IN OIL.

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INVESTIGATIONS

At one factory the writer observed that the fish in course of canning were for the most part mutilated, soft, and uneven, and were being put up in peanut oil, and learned that these sardines were destined for the American market.

Sealing the bottoms on the cans—the next step in the preserving process—is one of the few things done by men. Soldering appliances of various types are used in the different factories. The most convenient, time-saving, and modern soldering iron would appear to be that which is kept constantly heated by gas. The handle of the iron is pierced by two pipes, one conveying gas and the other air for admixture with the gas; and the gas is ignited in the head of the iron in such a way as to keep the soldering edge continually at a white heat. The free movement of the iron is effected by rubber tubes connecting it with the main supply pipes extending lengthwise under the table at which the solderer works. While being closed the can is held in a frame on a small turn-table moved by the foot of the solderer. The cover is applied so as to force out the air, and at the same time a good deal of oil escapes. The soldering begins in this oil, at the middle of one end of the can, and is continued around by the revolution of the turn-table rather than by the movement of the iron.

From the soldering table the cans are taken to another room in which they are placed in large square iron vessels, open at the top and holding several thousand "quart" cans. The vessels are then immersed in boiling water for two hours. This accomplishes a fourfold purpose: (1) The cooking of the fish is completed; (2) the bones are softened; (3) the bacteria in the oil and fish are killed, which would otherwise produce putrefaction; (4) the presence of leaks in the cans is disclosed.

After cooling, the cans are placed in dry sawdust and stirred from time to time; this absorbs the oil and moisture on the surface and renders the cans clean and ready for packing.

There is a comparatively small proportion of the fish prepared as "boneless sardines," which are rendered "boneless" by bending the caudal peduncle until the backbone breaks, and then drawing out the vertebral column with special tweezers or pincers. Fish intended for this purpose require more prolonged drying (2 to 3 hours), so that the muscular tissue may separate more completely from the vertebræ. Only fish 60 mm. long or over are made "boneless," and of even the larger fish only a small quantity is so treated. The best sardines are not so prepared, as they are fresher when they reach the cooking room, having required only one-half or one-third the time for preparation up to that stage. The "boneless" fish, while undergoing the additional drying, are deteriorating. The removal of the backbone adds about 6 per cent to the value of the fish, although the women who prepare them receive no additional wages.

Tin plate for sardine cans is manufactured at Nantes and other places in France. In Concarneau, Nantes, Hennebont, and elsewhere cans are made for the canneries at special establishments and are sent to the factories in the same boxes in which they are subsequently shipped when filled. At Hennebont there is a plant for the decoration of tin plate.

Most of the canning factories receive their cans ready-made, but some simply have the separate parts cut, and during winter give employment to the can-makers. Nearly all of the sardine cans are now provided with keys, which are placed on the cans as the sardines are boxed for market. The sardines of the best quality

have keys for use on the side or edge of the can, rather than on the top, which remove a thin strip of tin.

Labeling of French sardines is an important branch of the canning business, and although the use of labels is not required by French law, labeling is almost invariably practiced. The most popular and generally employed label is that which is stamped on the tin. Very few paper labels are used, and these are chiefly for special French trade. Some of the best grades of sardines are labeled with brass labels of oval or oblong shape, attached to the side of the cans by solder.

CANNERY EMPLOYEES AND THEIR WAGES.

The canning of sardines gives employment to many thousand persons, at what are considered good wages, and in some of the fishing towns gives work to practically all able-bodied persons who are not engaged in fishing. In Concarneau, a town of 10,000 people, fully 3,000 men, women, and children are directly connected with the sardine-canning business, besides the fishermen. The average number of employees at the factories in Brittany is over 100, and at the largest cannery in Concarneau about 335 persons are employed. Living in the fishing towns is very cheap. The principal diet is fish and bread, and meat is eaten usually but once a week.

Most of the work in connection with the canning of sardines is done by women and girls, a few men being employed for special duties for which women are not adapted (can-making, soldering, boxing, etc.), together with a small number of boys who are apprentices.

Among women and girls in the Brittany factories uniform wages prevail. The rate in 1900 was 1½ francs for each 1,000 fish, the aggregate being divided equally among employees. A good week's income for cutters and packers is 30 francs ($6).

The solderers, who seal on the tops of the cans, receive 1.50 francs for 100 cans. In winter many men devote their time to can-making and are paid 3 francs per 100 cans. Other employees about the factories are paid by the month and receive an average of 70 francs. A good solderer can seal 1,100 to 1,300 cans daily, and some men do considerably more. Boxes that are badly soldered are returned, and, with their contents, charged to the solderer, who is not allowed to sell them. M. Deyrolle-Guillou, of Concarneau, communicates the following interesting note on the work of apprentice solderers:

> I have heard of a solderer who could seal up 1,800 "quart" cans of sardines in a day, but an ordinarily good worker does about 1,300. It is very easy work to learn. I have recently spoken with a cannery director, who told me that he had six young apprentices of last year, one of whom can now (1900) solder 1,200 boxes in a day, two can do 1,100, two can do 1,000, and one can do 900. These are only 15 to 17 years old, and must be apprentices three years and get only half pay during that time, that is to say about 75 centimes for 100 "quarts" soldered up.

PRICES OF SARDINES.

In 1900 the sardine packers received an average of 50 francs per 100 "quart" cans for fish of good quality in "olive" oil; in 1899 the average price for the same goods was 43 francs per case. Some "quarts" in oil, however, bring as much as 100 francs per 100 cans, and retail in Paris at 2 francs per can. These are the fish with which special care is taken; they are brought to the factories early in the morning and are canned with the minimal amount of softening and deterioration. Fish intended for the average American trade are quoted at about 35 francs per case of 100 cans.

THE DRYING YARD OF A CANNERY. WOMEN WITH SARDINES ON GRILLS.

. During the first week of July, 1900, the wholesale prices of French sardines in New York were $10.50 to $14 per case for choice "quarter" oils, $6.75 to $11 for ordinary "quarter" oils, and $16 to $23 for boneless "halves." During the last week in December, 1900, the quotations were $8.50 to $12 for choice "quarter" oils, $7.25 to $11 for ordinary "quarter" oils, $14 to $17 for choice "halves," and $16 to $23 for boneless "halves."

COMPARISON OF FRENCH AND AMERICAN SARDINES.

Observation has shown that French sardines, when of the best quality, have a flavor and richness which make them preferable to any sardine prepared on the Atlantic coast of the United States from the young of the sea herring; French sardines of average grade, even when canned in peanut and cotton-seed oil, are much superior in palatability to the great bulk of the American output; while the cheaper grades of French sardines—which unfortunately find a ready market in the United States—are certainly not preferable to much of the native pack.

The conditions which underlie the general superiority of the French canned sardines, and the steps which may be adopted in America for narrowing the gap which now separates the product of the two countries, appear to the writer to be chiefly as follows:

(1) The methods adopted in the French sardine fishery result in the landing of the fish in excellent condition. This is the main object and is never lost sight of. The fish are caught singly in a delicate mesh, removed by hand, carefully kept on board the boats so as to avoid crowding and mashing, counted by hand into small baskets, taken to the factories within a few hours after being caught, and promptly put through the preserving processes, so that ordinarily the deterioration which ensues is not worthy of mention. The sardine fishery on the coast of Maine is a weir fishery and the unit of measure is not the individual fish, as in France, but the hogshead. A large number of fish—sometimes a vast school—may be in a weir at one time, and are often held in the weir for many hours, sometimes for several days, during which they are without food, are incessantly harassed by their fellows and by other fish, and necessarily undergo deterioration; they are then taken from the trap with large dip nets and transferred to the collecting boat, where they are piled deep in bins or in the hold, and are often many hours in reaching the cannery. There the unloading results in further mashing, crushing, and bruising, so that by the time the sardines reach the cooking room they have lost so much of their flavor and firmness that no amount of subsequent care and no kind of oil or spice can replace or restore their quality. Although fish are liable to more rapid decomposition after capture than any other class of food animals, there are no products with which greater liberties are taken, and none in which the lack of care results so disastrously; this is especially true of the American sardine, and, in the writer's opinion, is largely responsible for the unsatisfactory quality of the canned fish.

(2) In France the sardines caught in the early part of the season are not canned, because they are not in the best condition. It is only after the fish have become fat that they are considered suitable for canning. The fattening depends on an abundance of proper food, and along with it is an improvement in the flavor and general quality of the flesh. In the case of our sardines, fishing for the canneries is carried on from April to December, without reference to the fatness of the fish.

While the young sea herring is an excellent fish, it may be admitted that even when at its best its meat is inferior to that of the fat young pilchard in richness. The latter has a peculiar flavor which, to a considerable degree, is preserved in canning, and which probably can not be successfully imitated in the sea herring. However, the difference in flavor between the French and the American sardines, on which many persons lay much stress, appears to the writer to be of only secondary importance. The taste for French sardines has been acquired and perpetuated in the United States because of the long-continued unsatisfactory quality of American sardines. The herring is naturally no less wholesome than the pilchard; if it is caught for canning only when in prime condition, and if, in the form of canned sardines, it is placed on the markets with the minimum amount of deterioration and with such adjuvants in the way of oil, spices, etc., as may be suitable, it should and will receive ample recognition at home, and meet with a constantly increasing demand, at prices that now are hardly dreamed of.

The history of a few canneries on our east coast during recent years has shown that a very marked improvement in the quality of American sardines is entirely practicable and, furthermore, is highly appreciated by consumers, as evidenced by the much higher prices they are willing to pay and the steady demand beyond the capacity of the factories. With regard to the sardines of the Pacific coast of the United States, there is no reason why they should not, when properly canned, prove equal to the French fish in every respect. The high reputation which has been acquired by the comparatively small quantities packed in California during the past five or six years, and the excellent prices which they have commanded, argue well for the success of an extensive business.

AMERICAN BAIT FOR THE FRENCH SARDINE FISHERIES.

The matter of supplying bait for the extensive sardine fisheries of the French coast has received some little attention in a few New England towns during the last few years, resulting in a small increase in the trade; but the consumption of bait is so large, the demand is so great, and the prices are so remunerative, that the American trade should be very much extended, especially as the bait material is now a waste product and may readily be prepared at a trifling cost.

Upward of ten years ago the United States Commission of Fish and Fisheries brought this subject to the attention of the New England fishermen, but with no noteworthy results. Now, owing to a shortage of the cod catch in the country which furnishes the principal part of the bait supply, the opportunity is unusually favorable for our fishermen to enter the market and establish a permanent trade. Having recently visited the sardine district of France for the purpose of investigating the industry and having given special attention to the requirements of the sardine fishermen in the matter of bait, the writer here presents the results of his inquiries and observations with a view to show the benefits that will arise from the utilization of an article that is now generally thrown away.

The preparation of sardine bait from cod eggs is entirely feasible in all the coast States from New Jersey northward, and if proper precautions are observed the business should result in a very substantial increase in the incomes of many of our cod fishermen. There would seem to be a similar opportunity for fishermen in other fisheries and in other parts of the country. The eggs of the cod are an artificial food of the

sardine, and are not known to possess any properties, especially when salted, which make them an indispensable bait. So far as known, all fish eggs not over one-sixteenth of an inch in diameter are suitable for bait. Among the gadoid fishes, the haddock, the hake, the pollock, and the cusk should yield eggs not inferior to those of the cod. Reference has already been made to the value of mackerel eggs as bait. Many other common species inhabiting our salt or fresh waters might be mentioned.

Norwegian roe has for many years practically monopolized the trade, and is still the leading bait as regards quality, quantity used, and price. American roe, as such, is just as good and just as satisfactory to the sardine fishermen as the Norwegian, but, owing to certain differences—amounting to positive defects—in the methods of packing, it is far less acceptable than the Norwegian, and will inevitably bring much less money per barrel until other methods are observed. The roe brought in by the French fishermen of Newfoundland is inferior to the American.

A description of the manner of preparing cod roe, as practiced in Norway years ago, and of the improvements therein suggested by the French Government, has already been given. The features which give to the Norwegian roe the superiority which it has continued to maintain, and the points to which Americans must give careful consideration if they would hope to receive a fair share of the trade, appear to the writer to be as follows, after a critical comparison of the product of the two countries as seen in France:

(1) The Norwegian roe is closely packed in the barrels, and when the barrels are opened the sardine fishermen find them practically full. The roe is evidently salted on shore and then repacked and pressed in the barrels with some force; and after standing and settling the barrels are apparently filled again before being finally closed. Barrels of American roe, on the other hand, although the same size as the others, invariably contain less bait, owing to shrinkage incident to salting, to failure of the packers to properly fill them in the first place, or to both these causes combined. The roe is taken from the barrels and carried to the fishing-grounds in buckets. A barrel of Norwegian roe will fill eight buckets, while often a barrel of American roe will fill only five or six buckets. Barrels of Newfoundland roe, while larger than the Norwegian, often contain 20 to 25 pounds less of roe.

(2) Norwegian roe is packed dry, and remains dry unless it becomes very old. The barrels contain no undissolved salt and no free brine. The brine which may form after the closing of the barrels escapes through holes, about one-fourth inch in diameter, bored in the sides of the barrel. Barrels of American roe are either dry or may contain more or less brine; they are also liable to have considerable undissolved salt in the bottom or mixed with the roe. The barrels should contain nothing but dry roe, as the French fishermen are too economical and too keen to knowingly expend their hard-earned money for salt and water as bait for sardines. Small shipments of roe from America ten or more years ago were very unsatisfactory and gave rise to a well-founded prejudice which still prevails to a considerable extent. Barrels were occasionally found that contained very little roe and were filled chiefly with salt. "Salt is not good for sardine bait," was the remark of a dealer at Concarneau. The quality of American roe in the foregoing respect is now better, although, in the opinion of the fishermen, there is still much room for improvement.

(3) The Norwegians observe several grades of roe, depending on the ripeness of the eggs, and pack them in separate barrels, which bring different prices. The ripeness of the roe determines its quality as bait, because of the plus or minus of ovarian capsule or membrane, which is thinner and relatively less in quantity when the eggs are riper. With the American roe no distinction of this kind is made, but eggs of all degrees of ripeness are mixed. Large pieces of thick ovarian membrane are often found in the roe from the United States.

(4) The ovaries are salted more or less entire in Norway, and when a barrel is opened the individual organs may be removed one by one. As the roe needed for fishing is transferred from the barrels to the buckets by hand, the existence of the whole roe facilitates the work and is appreciated by the men. American roe is largely a concrete mass of wet eggs with strings of membranes running through it.

The foregoing considerations lead to the presentation of the following suggestions and information for persons who may be in position to undertake the preparation of bait for use in the sardine fishery:

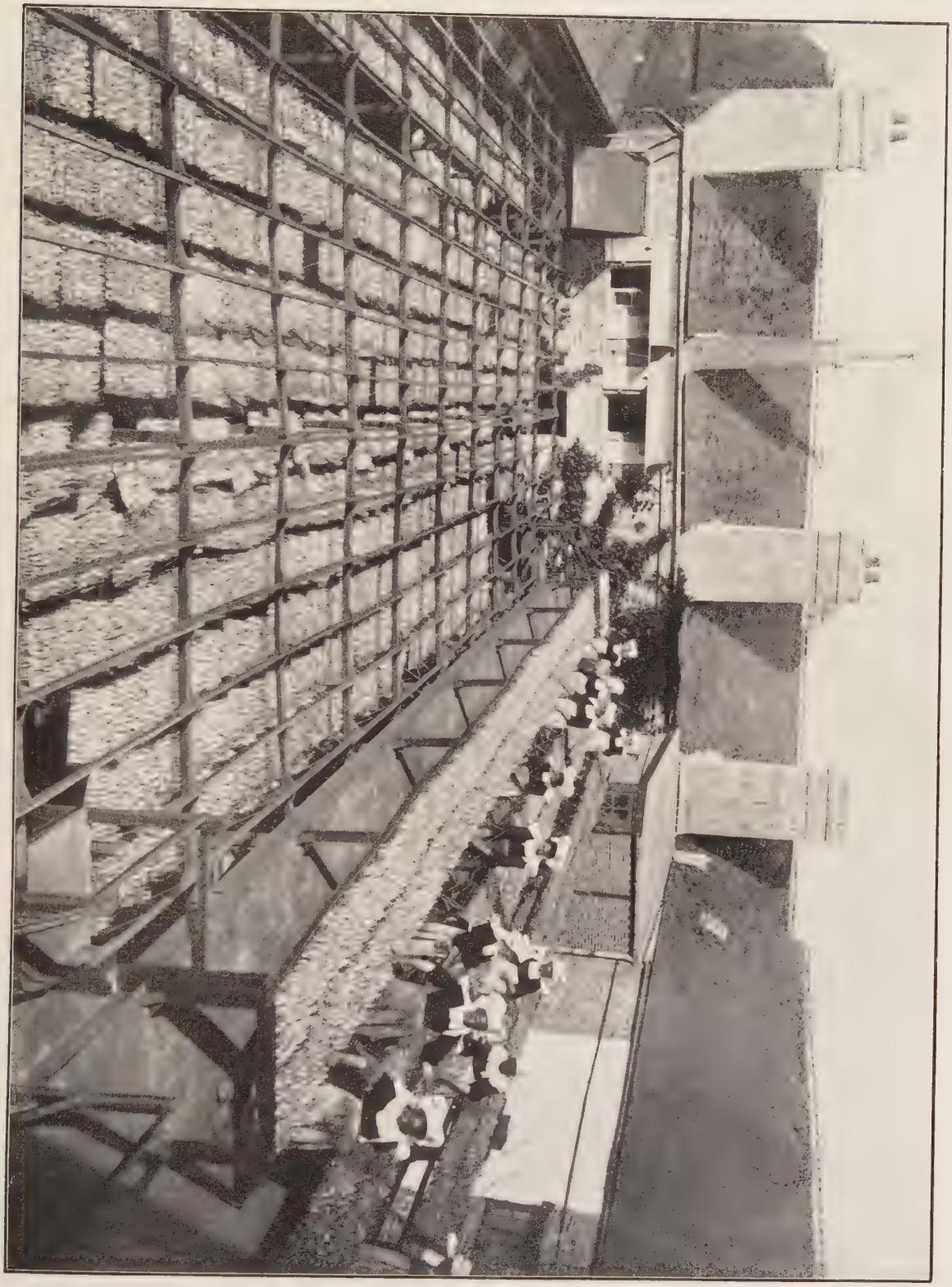
(*a*) Ovaries in which the eggs are sufficiently developed to be separable are suitable for bait. They should be removed and salted as soon as possible after the fish are caught. In the offshore vessel fisheries the roes may be salted loosely in barrels or vats, and repacked in suitable barrels after the vessels return to port. In the shore fisheries the salting may be deferred until the boats land their catch. When practicable, the ovaries should be removed entire and salted between layers of dry, rather fine, salt. The salting should be thorough, so that no salt need be put in the barrels in which the roe is shipped.

(*b*) The repacking of the roe is to be commended and will amply repay the extra labor involved. The barrels should be of uniform size, neat, and well made. While the size of the barrels is not a matter of much importance, the sardine fishermen have become accustomed to a barrel holding about 140 to 144 kilograms (308 to 316 pounds) of roe, and their preference should be borne in mind. Barrels should have not less than 300 pounds of roe, net, and should have no unoccupied space. The pressing of the roe, in order to completely fill the barrel, is desirable. Escape should be provided for the brine that may run from the eggs, by boring several small holes near the ends of the barrel.

(*c*) The grading of the eggs is recommended. Eggs of different degrees of ripeness and from different species should not be mixed in the same barrel. The amount of ovarian membrane should be reduced to a minimum; after salting, this can be stripped off more easily than when the eggs were fresh. Loose eggs, resulting from ovaries ruptured while fresh or in process of salting, should be packed in separate barrels.

(*d*) The barrels should be marked with the name of the packer, together with the kind and grade of the roe. The eggs of all the members of the cod family may properly be labeled "cod." The net weight of the roe (in kilograms) might also be put on each barrel. Packers desirous of establishing and increasing their trade will of course see that no discrepancy exists between the contents of the barrels and the marks on the outside.

(*e*) American bait now goes by steamer to Havre and thence by rail to the fishing towns. The freight on a barrel of roe from Havre to Concarneau is 6 francs. Roe might be sent directly to the fishing towns, or to some center on the west coast, from which it might be distributed at less cost than from Havre. The present duty on roe is about 1 franc per barrel of 144 kilograms. Bait-dealers or agents may be found in all the leading fishing towns. It is reported that they make a net profit of 20 per cent on the roe handled.



YARD OF A LARGE CANNERY, SHOWING SARDINES DRYING ON GRILLS.

Contributions from the Biological Laboratory of the U. S. Fish Commission,
Woods Hole, Massachusetts.

BIOLOGICAL NOTES.

No. 2. Issued August, 1901.

NOTES ON THE MIGRATION, SPAWNING, ABUNDANCE, ETC., OF CERTAIN FISHES IN 1900.

By George H. Sherwood and Vinal N. Edwards.

Observations on the habits, abundance, spawning, migrations, and on the influence of physical changes on these phenomena, are here presented for a number of fishes of the Woods Hole region during the season of 1900:

Tarpon atlanticus, *Tarpon.*

Mr. H. M. Knowles, of Wakefield, R. I., is authority for the statement that a tarpon 5 feet long, and so slender that it weighed only 30 pounds, was caught in a fish trap near Dutch Island Harbor, Narragansett Bay. Another weighing 80 pounds was taken at Marthas Vineyard, and a smaller one in the Fish Commission trap at Woods Hole. The northern limit of range of this species is southern New England, but it probably does not breed north of Cuba.

Brevoortia tyrannus, *Menhaden.*

Although the menhaden season of 1900 was regarded as the most successful in three years, the fish were exceedingly scarce in this vicinity, particularly during the last of August, at which time it was impossible to procure any, either in Boston or Newport; and on this account a contemplated trip to the tile-fish grounds had to be postponed. In Buzzards Bay, however, where all net fishing is prohibited by law, large schools were present all summer.

Hippocampus hudsonius, *Sea-horse.*

In August a fine specimen of *Hippocampus* was dredged by the U. S. Fish Commission steamer *Fish Hawk*, outside of Devils Bridge, Gay Head. It was taken to the laboratory and lived for several days in the aquarium. This is the only one caught for several years.

Scomber scombrus, *Mackerel.*

Notwithstanding the catch of mackerel along the Atlantic coast was phenomenal, very few were taken in inshore waters. Even the traps far from the shore off Seaconnet and Newport took scarcely any. The failure of the mackerel to enter Buzzards Bay and Vineyard Sound is to be attributed in all probability to the remarkable scarcity of small fish of all kinds. Indeed, seining has never resulted in the capture of fewer small and young fish than in 1900.

The first mackerel reached Chatham April 29, and on the following day were taken at Cuttyhunk and Menemsha. The temperature of the water at Woods Hole at this time was 46° F., although 50° F. is apparently more favorable for them. The presence of so many spawning fish near the coast in 1900 led one to expect that young mackerel would be numerous, but this was not the case. On July 9 a few young mackerel 2.5 to 3 inches in length were seen in a trap at Woods Hole, but in a few days they disappeared and no more were recorded in the vicinity until late in the fall, and even then only in small numbers.

As throwing some light on the question of the equatorial migration of the mackerel, it is of interest that in 1898 they appeared at Seaconnet, R. I., Chatham, Mass., and Yarmouth, Nova Scotia, on the same day, May 3.

Sarda sarda, *Bonito.*

Seventy-five bonito from a trap at Cedar Tree Neck on June 18, 1900, were reported to be the first arrivals of the season, and throughout the summer on almost every clear day the schools were breaking at the surface from Gay Head to Woods Hole. On account of the peculiar flavor of its flesh the bonito has not found a ready market, but it is growing in favor. In 1900 there was a considerable demand for it, and it brought even better prices than the squeteague. The indications are that the bonito may largely supplant the latter as an article of food.

Scomberomorus maculatus, *Spanish Mackerel.*

This delicious food-fish, once quite abundant in Buzzards Bay, is now very scarce. One was taken in the Fish Commission trap in 1898, and three were caught at different times during the summer of 1900 in the trap in Vineyard Sound. These were all small fish, weighing 1.5 to 2 pounds.

Trichiurus lepturus, *Cutlas-fish.*

A specimen 3 feet 8 inches in length was caught in a trap off Newport. Several smaller specimens, which were also caught in Narragansett Bay, were sent to the Rhode Island Fish Commission. In October one was taken in a trap at Menemsha.

Pomatomus saltatrix, *Blue-fish.*

In a note on the abundance of the squeteague reference is made to the gradual decrease in the numbers of blue-fish which enter the waters of Buzzards Bay and Vineyard Sound. Simultaneously with this change there has occurred another, equally difficult to explain, in the time of their arrival. Some twenty years ago the fish were sure to be taken in the traps the first or second week in May, while recently they may be as late as the middle of June. The presence of large schools of blue-fish off Nantucket and No Mans Land all summer makes it evident that they have not completely deserted our coast; but just why so few come inshore and why they are so much later in their arrival is not apparent. In spite of the scarcity of mature fish the young have been very abundant everywhere, and particularly at Katama Bay, where undoubtedly they have destroyed many of the rare bright-colored southern forms referred to in Biological Notes No. 1. The rate of growth of the young, as found in Katama Bay in 1900, is as follows: July 27th, 3 inches; August 8th, 3 to 5 inches; August 29th, 5 to 7 inches; September 24th, 7 to 9 inches; October 3d, 8 to 11 inches.

Centropristes striatus, *Sea Bass.*

It is to be regretted that this gamy fish is decreasing so rapidly in numbers. In a short time it will probably become a rare species in this locality. Hand-lining, even on the spawning-grounds off Hyannis, was remarkably poor this season, and the abundance of the young does not give promise for the coming year. As a rule the first adults appear in their seasonal migration during the first or second week in May, when the water has reached a temperature of 48° to 50° F. However, in spite of the cold of 1900, they appeared at Cuttyhunk and Menemsha Bight on April 28—with one exception the earliest arrival recorded in twenty-five years. Formerly the young were abundant everywhere, but at present they are restricted to a few localities—Katama Bay, Quisset Harbor, and Wareham River. The first fry were seined July 31 and measured three-fourths of an inch in length. On the 20th of October young fish 2 to 3 inches long were very plentiful in Katama Bay.

Lobotes surinamensis, *Flasher, Triple-tail.*

The Rhode Island Fish Commission has in its possession a specimen of *Lobotes* weighing 6 pounds and measuring 22 inches in length, caught on September 10 in a trap off Prudence Island, Narragansett Bay. This inhabitant of all tropical seas is a very rare visitor in the waters of southern New England. Not more than six specimens have been recorded from this vicinity in the last twenty years.

Stenotomus chrysops, *Scup.*

The catch of scup this year has been good, but not extraordinary. The first arrivals were taken off Newport April 21, at Cuttyhunk April 26, and five days later at Woods Hole. This was an average arrival, although the water was 2° to 3° F. below the average. The adult fish usually leave in October, while the young may remain a month or more longer. Hundreds of the latter are killed every year by the sudden changes of temperature.

The growth of fry as observed at Woods Hole is as follows: July 3d, 0.5 to 1.5 inches; August 2d, 1.5 to 2 inches; September 6th, 2 to 3 inches; September 29th, 3 to 4 inches; November 1st, 4 inches.

Roccus lineatus, *Striped Bass.*

Three specimens of striped bass were caught in the Fish Commission trap on July 21, 1900. The largest weighed 20 pounds. Several others were taken by the summer sportsmen with hook and line, and at Cuttyhunk they were reported as large and more plentiful than usual.

Cynoscion regalis, *Squeteague.*

The first squeteague of the season were taken at Cuttyhunk on May 5, 1900, and nine days later they reached Woods Hole. The water temperature at this time was 50° F. Compared with previous years, the arrival was a little later than usual; but since the temperature of the water during the spring was below the average, this was to be expected. As a rule, the first run of squeteague, like that of other migratory species, is composed of large adult fish, while the yearlings appear about two weeks later. During the spring of 1900, however, the reverse was true, small fish, weighing from 2 to 3 pounds, coming first. Toward the last of May, during the run of large fish, one was caught at Cuttyhunk which weighed 14 pounds. The abundance of the squeteague was remarkable. In the Menemsha traps alone 10,000 were taken in a single day (July 31); and, in fact, they were so plenty throughout the season that they ruined their own market and did not bring enough to pay the shipping bills. Many of the Vineyard fishermen retained the fish in the pockets, waiting for better prices, but a heavy northeast storm tore up the nets in the fall, and most of the summer's catch was lost.

Observations on the first appearance of the fry, their growth, and their abundance have been continued. The results are given in the following table, although much more complete data have been collected by Professor Eigenmann. The rate of growth corresponded with that of the blue-fish:

Date.	Locality.	Length.		
		Inches.		
July 25	Wareham River	1.25 to 2.25		Very scarce.
Aug. 2	do	2	3	Do.
Aug. 5	Red Bridge, Providence River	1.25	2.25	Abundant.
Aug. 22	Wareham River (farther up)	3.75	5	Very scarce.
Oct. 5	Acushnet River	6	7.25	Do.

When, a few years ago, a bill to prohibit all net fishing in Buzzards Bay was presented to the Massachusetts legislature, one of the strongest arguments of its supporters was that the bay was the natural spawning-ground of the food-fishes, and therefore their decrease was attributed to excessive trap fishing. A careful study of the records of the movements of the squeteague for the last thirty years has revealed some striking facts which have an important bearing on this question. Notwithstanding protective legislation, it is very evident that breeding squeteague have ceased to enter Buzzards Bay in any considerable numbers; for while twenty years ago the young could be seined almost anywhere in the vicinity of Woods Hole (at Great Harbor, Hadley Harbor, Nobska Beach, and Quisset), there are now only two localities in Buzzards Bay and Vineyard Sound where they are found—at Wareham, near the head of the bay, and in Acushnet River, on the New Bedford side. Even in these places their numbers are greatly reduced.

The former abundance of the young was due in all probability to the fact that the adults spawned in the open bay or outside waters, and since the buoyant eggs were subject to the influence of winds and currents, they were carried hither and thither until finally lodged in the protected harbors and inlets. Such conditions would tend to distribute the eggs more or less uniformly along the shores of the bay, and the fry would not be restricted to the present areas. On the other hand, with the remarkable increase of the adults, if they still continued to spawn in the same places, there would have been a correspondingly large increase of the young.

It may be argued that the spawn is deposited in the same places as formerly, but that the eggs merely drift into the estuaries—Wareham River and Acushnet River. But this does not seem at all probable, since the outward current in these rivers is stronger and longer continued than the inward. A more plausible explanation is that the few adults entering these rivers find conditions favorable, and therefore spawn, while the great majority of the fish seek other localities. The Rhode Island fishermen who control the sea traps off Seaconnet and Newport say that whereas years ago they used to catch plenty of squeteague at the mouth of the bay, very few are ever seen there now. They believe that the fish no longer run in *offshore waters,* but enter the bays and inlets. Substantiating

this is the extraordinary abundance of the fry during the past few years in Narragansett Bay, particularly in its upper part, near Red Bridge and India Point. Even here great numbers of them were killed in 1900 by *Peridinium*. For two weeks or more in September this small protozoan infested the waters of the upper bay in such numbers that the water was almost a blood-red color, and as a result young squeteague, together with fish of several other species, were piled in windrows on the shore. There is but one conclusion to be drawn from the foregoing facts—the squeteague has changed its spawning-grounds within a few years, and, judging from the abundance of the young, Narragansett Bay is the more favorable locality at the present time.

The study of the yearly records has also shown that a definite relation exists between the abundance of squeteague and blue-fish. Twenty years ago 100 squeteague were considered a remarkable catch, but now it is not uncommon to take 4,000 at a single draft of a trap. On the other hand, twenty years ago blue-fish were so plentiful that barrels of them were shipped daily, while in 1900 not over 50 were recorded from the bay or sound. There can be but little doubt that the marvelous increase of the squeteague has been made possible by the disappearance of one of its most dangerous enemies—the savage blue-fish.

Tautogolabrus adspersus, *Cunner.*

Barrels of cunners were killed by the extreme cold of February, 1901, and were seen floating on the surface with the tautog.

Tautoga onitis, *Tautog.*

Fewer tautog were caught in the vicinity of Woods Hole than last year. In fact, many hook-and-line fishermen were compelled to seek other employment, but just the reverse obtained in Narragansett Bay. According to the report of the Rhode Island Fish Commission for 1900, the tautog in Narragansett Bay were very abundant and of large size, some weighing 13 pounds. Capt. Isaac L. Church, of Tiverton, R. I., who has followed tautog fishing for many years, says that they are as abundant now as they ever were. Young tautog were numerous along all shores during the summer, but more particularly at Katama Bay, where they actually occurred in shoals. For several days in February, 1901, tautog were found floating on the surface, evidently killed by the anchor ice, which formed nearly all the month. The outlook for next season's fishing is less promising than ever.

Lagocephalus lævigatus, *Smooth Puffer.*

During 1900 several specimens of this occasional visitor were taken in the vicinity of Woods Hole. In the fall two adults were caught in a trap at Cedar Tree Neck. The Rhode Island Fish Commission reports three specimens from Narragansett Bay; the largest, taken October 4 at Tiverton, R. I., weighed 10 pounds; the other two were caught the week before at the mouth of the bay. The smooth puffers are common in the South, but very rare north of Cape Hatteras. Their average length is 2 feet. The young from 2.5 to 4 inches long were found by the U. S. Fish Commission in the waters of Porto Rico.

Pollachius virens, *Pollock.*

During the spring of 1900 the young appeared as usual with the small cod. Years ago the adults were plenty in the sound, but now only a few stragglers are seen.

Microgadus tomcod, *Tomcod.*

The tomcod during the winter of 1900–1901 were entirely free from parasites (*Lernæonema radiata*). Some seasons nearly all the fish are infected.

Gadus callarias, *Cod.*

The number of cod taken in Vineyard Sound during the fall of 1900 was unprecedented. Off Bowbell Ledge the fishermen gave up fishing for tautog and made cod fishing their business. The cod were all plump and in good condition, weighing from 4 to 20 pounds. In Great Harbor, where the cod seldom enter, they were so plenty that 10 specimens were taken in the fyke nets in October, 15 were taken in November, and 45 in December. With one exception these were good marketable fish, weighing from 4 to 16 pounds, and were quite different from the thin, flabby specimens occasionally taken here. Five were spawners.

That the cod have not decreased off Nantucket is evidenced by the remarkable catch made by the *Grampus* in this locality during November and December, 1900. More than 3,000 brood cod were brought back to the station for the hatching season. The cod were equally abundant around No Man's

Land, but the fisheries were a failure because of the scarcity of bait. Herring were not running and quahogs could not be obtained in sufficient numbers.

On January 30, 1901, 500 to 600 cod, of which 48 had been stripped and the remainder were barren fish, were left in the cars to be tagged. On the following day there was a fall of snow and the temperature of the water began to fall from 31° F. and for the greater part of February remained at 28° F. Ice was formed in the harbor and all the cod died. This would go to show that the cod adapt themselves to abrupt changes in temperature by migrating to deeper water.

Rhinonemus cimbrius, *Four-bearded Rockling.*

Young rockling were taken in the surface towings at the Fish Commission wharf from June 27 to July 6, 1900. They formed in schools in the eddies around the wall and were mixed with young sticklebacks (*Gasterosteus bispinosus*). Their length was 0.5 to 1.375 inches. The rockling is found in all North Atlantic waters, and although it is said to be abundant in Massachusetts Bay, only two specimens have been reported from Woods Hole. One measuring 10 inches in length was speared in the Eel Pond January 5, 1889; the second was caught in Little Harbor also in the winter, but there is no record of the exact date. The young have never before been taken here.

Hippoglossus hippoglossus, *Halibut.*

On April 16, 1900, there was brought into Newport a halibut weighing 100 pounds, which with others was caught off Block Island by cod-fishermen. Halibut were formerly abundant in this locality and in Vineyard Sound, but none have been taken for several years. This catch leads one to hope that this valuable food-fish may return to its old grounds.

Pseudopleuronectes americanus, *Flat-fish.*

An illustration of the effect of a sudden fall of temperature on the behavior of fish was given in February and March, 1900. The flat-fish had been plentiful both at Great Harbor and Waquoit Bay throughout February up to the 23d, when they entirely disappeared, and none were taken again until March 6. The records show that after the 23d the temperature of the water dropped from 35° F. to 29° F., and that on March 6 it rose again to 32° F.

The normal breeding season of flat-fish is from February to May, and it is very unusual to find them with mature sexual products before January; but in 1900 seven specimens of the hatch of 1898, caught in Eel Pond on November 20, had ripe milt. Again, on November 27, three out of four flat-fish caught in a fyke net set in Great Harbor were ripe milters, and on the following day, at the same place, two females were taken, swollen with eggs, and in such condition that had they been taken in February they probably would have spawned within two days. Never before have flat-fish with ripe sperm been taken so early, and it is possible that the unusually warm water of October and November, 1900, may have caused this premature development of eggs and milt. The last flat-fish with ripe eggs for the season of 1899–1900 was taken April 25. Although it is generally believed that flat-fish extrude their eggs only at night, on March 14, 1901, a large fish, which had been in the fish-boxes at the hatchery a day or two, spawned in the middle of the afternoon.

In regard to the "black-bellied" fish, the report of the Rhode Island Fish Commission for 1900 states: "It is an extremely interesting fact that the dark-bellied variety, which gradually came into notice several years ago and attained the maximum of its abundance in 1898, is on the decline. Last season, according to a trustworthy estimate, only about 4 per cent were colored on the under surface, while three years ago at least 33 per cent were so colored." Among 300 flat-fish from Waquoit Bay this season (1900–1901) there was not a single specimen of the black-bellied variety, although last year Dr. Bumpus reported several. This variation seems to have completely disappeared.

A young flat-fish, 1.5 inches long, was seined at Katama Bay August 15, 1900; the posterior two-thirds of its upper surface was devoid of pigment, and a distinct line separated the two areas. The scales were different in structure from the normal, and the presence of a deep notch on the dorsal side of the tail suggested that the lack of pigment may have been produced through injury or disease, although the surface was apparently free from any lesion. This is the first time that this variation has been observed, although Mr. Edwards has seined in the vicinity of Woods Hole for thirty years.

Lophius piscatorius, *Goose-fish.*

During the fall of 1900, goose-fish were very abundant in Great Harbor, and late in the fall several large ones were washed ashore. This is of considerable interest, because the fish is not often seen near Woods Hole, although numerous at Menemsha and Cuttyhunk, where the shores are frequently lined with their bleached skeletons.

ADDITIONS TO THE FISH FAUNA IN 1900.

By Hugh M. Smith.

The already surprisingly large fish fauna of the Woods Hole region was augmented by four southern species during the fall of 1900. These bring the total number of species known from the vicinity to 243. Following are the species new to the region:

Exocœtus rondeletii (Cuvier & Valenciennes). *Flying-fish.*

This common species of the West Indies and the Mediterranean has been recorded from United States waters only in Florida. A specimen 7.25 inches long was caught in a trap at Menemsha Bight, October 13.

Ocyurus chrysurus (Bloch). *Yellow-tail.*

The normal range of this species is southern Florida to South America. It is an abundant food-fish at Key West. On October 4, an example 5.5 inches long was seined in Katama Bay.

Scarus croicensis (Bloch). *Parrot-fish.*

This is a common West Indian species, the northern limit of whose known range heretofore has been Key West. Two specimens 3 inches long were taken in Katama Bay, October 20, the water temperature being 57° F.

Sparisoma flavescens (Bloch & Schneider). *Mud Parrot-fish.*

This, the commonest species of the genus, is abundant at Key West and throughout the West Indies. It was not known north of Florida until a specimen 6 inches long was found at Woods Hole on November 13; it had been benumbed by the cold and was picked up on the shore of Buzzards Bay.

NOTES ON THE SUBTROPICAL FISHES OBSERVED IN 1900.

By Hugh M. Smith.

The season as a whole was unfavorable, and compared with 1899 there was a scarcity of tropical species. No gulf weed was seen in any of the inshore waters, and there was little wind from the direction of the Gulf Stream. Nevertheless, some rare fishes were found, and a number of species which until 1899 had been considered very uncommon were taken in abundance. Most of the collecting was done in Katama Bay, which the previous season's experience had shown to be the most favorable locality in the vicinity of Woods Hole, and only in this body of water were any of the typical southern fishes found. Large blue-fish and flounders were abundant at the inlet of the bay through the summer, and may have picked up many of the small gaily-colored stragglers from the south.

Clupanodon pseudohispanicus (Poey). *Spanish Sardine.*

There was a sudden fall of temperature on November 16, and a number of these fish, 5 to 6 inches long, were picked up on the shore in a benumbed condition; these were the first specimens observed in four or five years.

Holocentrus sp. *Squirrel-fish.*

One very small specimen, apparently representing the same species as the one taken in 1899, was obtained August 28.

Epinephelus niveatus (Cuvier & Valenciennes). *Snowy Grouper.*

Thirty-five small specimens were seined in Katama Bay on nine occasions between August 15 and October 26. The largest number taken during one day was 12, on September 8.

Epinephelus morio (Cuvier & Valenciennes). *Red Grouper.*

A small specimen, similar in size and appearance to those obtained in the same locality in 1899, was taken September 26.

Mycteroperca bonaci (Poey). *Marbled Rock-fish.*

One specimen, 3 inches long, was taken August 15.

Mycteroperca venenosa (Linnæus). *Yellow-finned Grouper.*

Eight small specimens were secured on four different days (August 8 and 28, September 8, and October 20).

Pseudopriacanthus altus Gill. *Short Big-eye.*

Comparatively rare, only 9 being observed between August 15 and September 8, whereas in the previous year over 100 were taken.

Neomænis griseus (Linnæus). *Gray Snapper.*

Five specimens, the largest 1.875 inches long, were seined in Katama Bay on August 29. The general color is pale, with 6 or 8 narrow, dark, longitudinal stripes; spinous dorsal fin dark, with a sharply defined blackish bar involving the distal part of the fin, the extreme edge being white. Only two specimens, taken in September, 1897, were previously obtained in this region. The species appears to range normally as far north as Chesapeake Bay.

Neomænis apodus (Walbaum). *Schoolmaster.*

There has been only one previous record of the occurrence of this snapper north of Florida—namely, September 20, 1888, when an example 5.5 inches long was taken at Woods Hole. On August 29 and September 11, 1900, two specimens, 1 inch and 1.5 inches long, respectively, were caught in Katama Bay. The general color of the body is pale yellow, with 6 to 8 dark crossbands; a dark line extends from snout through eye to upper end of gill opening; several narrow dark lines run on head posterior to eye; anal fin red.

Neomænis blackfordi (Goode & Bean). *Red Snapper.*

Nine specimens, the largest under 2 inches long, were seined September 7, September 11, and October 20. Their colors in life were as follows: General color, red like the adult fish; body marked by about 7 double dark crossbands; in the crossband nearest the junction of the two parts of the dorsal fin is a large jet-black blotch extending from the fin to below the lateral line; spinous dorsal dusky; soft dorsal with a dusky median zone and a dark edge; caudal pale, with a dark narrow border. The only other red snapper recorded for this region is a specimen weighing 8.5 pounds, taken in October, 1890.

Neomænis analis (Cuvier & Valenciennes). *Mutton-fish.*

Twenty specimens of this snapper were taken, between August 28 and October 12, the largest being 2 inches long. These resemble the young red snapper in being banded and having a black lateral spot; the bands, however, are rather broader and more sharply defined, and the spot is smaller, less distinct, and does not extend to the median line of the back. This species was regarded as very rare until 1899, when more than 20 small examples were observed.

Chætodon ocellatus Bloch. *Butterfly-fish.*

This species, formerly a rare straggler, must now be regarded as common, in the light of the experience of the past few years. In 1900 123 specimens were taken, the fish being found in Katama Bay on 13 different occasions between August 15 and October 26; 26 were seined on September 8, and 21 on October 3.

Chætodon bricei Smith. *Butterfly-fish.*

About 35 were observed on ten different days, in company with the preceding species.

Teuthis cœruleus (Bloch & Schneider). *Blue Tang.*

Teuthis hepatus Linnæus. *Tang.*

Teuthis bahianus (Castlenau). *Tang.*

A few specimens of each of these species were taken in August, September, and October. They were last observed on October 3, when one of each was secured.

Lactophrys tricornis (Linnæus). *Cow-fish.*

Two specimens only 0.25 of an inch long were taken October 4.

Scorpæna plumieri Bloch. *Scorpion-fish.*

Two small specimens were obtained October 20 and 26.

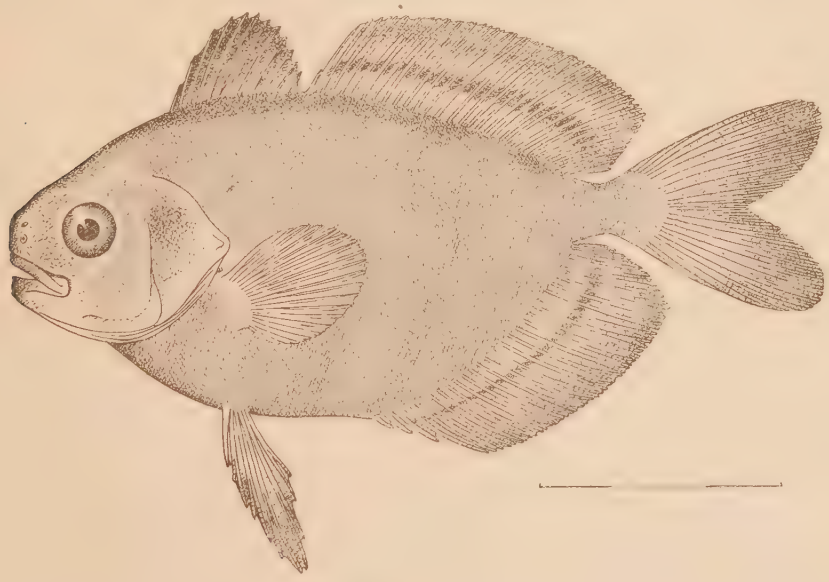
Contributions from the Biological Laboratory of the U. S. Fish Commission,
Woods Hole, Massachusetts.

DESCRIPTION OF A NEW OCEANIC FISH FOUND OFF SOUTHERN NEW ENGLAND.

By CARL H. EIGENMANN,
Professor of Zoology, University of Indiana.

Psenes edwardsii, sp. nov.

Head 3; depth 2; D. XII–I, 30; A. III, 28; V. I, 5; lateral line about 140. Depth of head over middle of eye little less than its length; eye 1 in snout, 3.6 in head, 1.4 in interorbital; width of body at axils 2.5 in length of head; maxillary reaching front of eye; no adipose lid; top of head fatty, with few pores; pectoral broadly rounded,



Psenes edwardsii.

1.5 in head; ventral shorter than head by half diameter of eye; highest dorsal spine 2 in head; highest dorsal ray 1.75 in head. Translucent; back thickly covered with pigment cells; these extend below the lateral line, and along base of anal; abdominal region entirely free from pigment; spinous dorsal, ventrals, and caudal dark; other fins dusky; a dark band on the soft dorsal and anal just beyond the scaly base.

Type (No. 49745, U.S.N.M.), a single specimen, 90 mm. long, taken about July 28, 1900, by the schooner *Grampus*, from under a medusa, 30 miles south of Newport, Rhode Island. This species is evidently closely related to *Psenes pellucidus*, from which it differs in the longer snout, smaller eye, fewer fin rays, rounded fins, etc.

I take great pleasure in associating with this species the name of Mr. Vinal N. Edwards, who has been connected with the U. S. Fish Commission as collector since its establishment thirty years ago, and who assisted Prof. S. F. Baird as collector before the establishment of the Commission.

The genus *Psenes* is distinguished by Goode & Bean (Oceanic Ichthyology, p. 219) from *Nomeus* and other genera of the *Nomeidæ* by "Pectorals long, surpassing ventrals * * *," but in their description and figure of *Psenes pellucidus* the ventrals are given as 5 mm. longer than the pectorals. The first dorsal of *Psenes* is said to possess 6 to 10 spines, while *Psenes pellucidus* is figured as possessing 12 spines. In the description of the family of *Nomeidæ* the palate is said to possess teeth, while in their description of the genus *Psenes* teeth are described for the jaws only. These mistakes are repeated by Jordan & Evermann in The Fishes of North and Middle America (pp. 948–950). In their synopsis of the families of the *Scombroidei*, Jordan & Evermann (p. 863) distinguish the *Nomeidæ* from the *Stromateidæ* by the absence in the latter of tooth-like processes in the œsophagus. The specimen of *Psenes* under consideration has an enlarged œsophagus with denticles like those found in the *Stromateidæ*. As far as I am able to make out in small specimens of *Nomeus* the œsophagus is similarly modified. The *Nomeidæ* are readily distinguished from the *Stromateidæ* by their large number of vertebræ.

Contributions from the Biological Laboratory of the U. S. Fish Commission,
Woods Hole, Massachusetts.

THE EGG AND DEVELOPMENT OF THE CONGER EEL.

By CARL H. EIGENMANN,
Professor of Zoology, University of Indiana.

On July 31, 1900, at 10 o'clock a. m., the U. S. Fish Commission schooner *Grampus*, while on the tile-fish grounds about 30 miles south of South Shoal, secured some pelagic fish eggs. These eggs were collected by Dr. Porter E. Sargent. Among them were many which he supposed to be the eggs of the tile-fish, which they resembled in many respects.[1] They were brought to the Woods Hole laboratory on August 1. It was soon seen that they were the eggs of some eel, and since no eel eggs had been observed in American waters, in fact, none outside a limited region in the Mediterranean, it seemed doubly desirable to follow their development.

When the eggs were secured, the gastrula was said to cover about half of the yolk. On August 1 the tail was well developed. During the night between August 2 and 3 many of them hatched. The last one died in the night between August 13 and 14. The eggs were divided into two lots on August 1. Some were left in running sea water, others placed in a shallow dish of standing water. Since, on August 2, many of those in the running water had died while none of those in standing water perished, they were all placed in standing water, which was occasionally changed.

Before describing these eggs more in detail, a brief review of the eel-development question may be given. The ancient history is given fully by Jacoby.[2] The modern history begins with the discovery of Raffaele,[3] who in 1888 described five species of pelagic fish eggs secured during August, September, October, and November, which, on account of the character of the larvæ they produced, he referred to species of eels. This is the first description of the developing eggs of any eel-like fishes. The common characters of the eggs described by Raffaele are: (1) Their large size; (2) the large perivitelline space; (3) the delicate membrane lacking pore canals and usually with iridescent reflections; (4) the vesicular yolk. They differed from each other in size and in the possession or absence of an oil-sphere.

The eggs and larvæ derived from the eggs secured by Raffaele were characterized as follows: No. 6 had a large perivitelline space, diameter of the eggs 2 to 2.5 mm., diameter of the vitellus 1.20 to 1.50 mm., 1 to 3 oil-spheres of 0.30 to 0.35 mm. The larva developing from this possessed 72 (or 73) abdominal segments. No. 7 had a

[1] Ripe eggs taken from a tile-fish and preserved in formalin measure as follows: The yellow oil-sphere 0.2 mm., the yolk 1.09 mm., from membrane to membrane 1.25 mm. The eggs are much smaller than those of the eel here described.

[2] Report U. S. Fish Commission, 1879.

[3] Le Uova Galleggianti e le Larve dei Teleostei nel Golfo di Napoli. Mittheilungen aus der Zool. Station zu Neapel, 8, pp. 1–84, tav. 1–5.

diameter of 3 mm., 6 to 12 oil-spheres which occupied the posterior (ventro-anterior in the figure) part of the vitellus when the embryo developed; 59 (60?) abdominal segments were developed. No. 8 had a diameter of 2 mm. and about 30 oil-spheres; the larva had 72 (73?) abdominal segments. No. 9 had a diameter of 2 mm., the yolk attached to the membrane by filaments; when the young developed, the oil-sphere occupied an anterior position and had the form of a club; 66 (67?) abdominal segments; larva much smaller than that of No. 6. No. 10 had a diameter of 2.7 mm., was without oil-sphere, and yielded a larva with 44 (45?) abdominal segments.

All of these were taken between August and November, being more abundant in September and October. The earlier stages had a well-formed blastodermic callote. The yolk becomes well constricted after the blastodermic rim has passed the equator. The larvæ had a number of characters in common, viz, an enormous fourth ventricle, a large œsophageal pouch, an elongate body with numerous abdominal segments, the position of the anus about halfway to the margin of the ventral fin fold, very large and striking teeth, and a series of pigment spots along the lower parts of the sides.

When the larva is five or six days old it is slender and elongated, with a greatly compressed body, very transparent, and with little pigment. The vitellus is very elongated and diminishes from in front backwards. The intestine ends in the ventral fin fold a short distance from the body in a small accumulation of cells. The notochord is formed of a single series of segments. The mouth opens during the second day after hatching. The teeth develop rapidly. Three pairs are developed in the upper jaw. This dentition is absolutely exceptional among fishes. Contemporaneously with the development of the mouth the choroidal pigment and five or six black pigmented spots form along the body. No noteworthy changes take place between the fourth and fifth days after hatching. Beyond this time Raffaele was unable to rear the eggs. He supposed these eggs to be those of eels, without more closely identifying them. Grassi, in his epoch-making researches in eel development,[1] identified Raffaele's egg No. 10, without oil-spheres and with a diameter of 2.7 mm., as that of the common European eel, *Anguilla vulgaris*. While unable to keep eggs like those described by Raffaele—which he secured at Naples—alive for many days, he showed that the newly hatched larvæ described by Raffaele have essentially the character of *Leptocephali*. He states that females of eels can only mature in very profound depths, i. e., at least a depth of 500 meters. The male can mature in shallow water:

> Fertilization takes place at great depths; the eggs float in the water; nevertheless they remain at a great depth in the sea, and only exceptionally, for unknown reasons, some of them mount to the surface. From the egg issue rapidly a præ-larva, which becomes a larva (*Leptocephalus*) with the anus and urinary opening near the tip of the tail. The larva then becomes a hemi-larva, the two apertures just named moving their position toward the anterior part of the body, which becomes thickened and nearly round. By further change the hemi-larva assumes the definitive or adult form. The larva, as well as the hemi-larva, shows a length of body much greater than that exhibited by the young Muræenoid of adult form into which they are transformed. By keeping specimens in an aquarium I was able to establish a diminution of more than 4 cm. during the metamorphosis. With regard to the greatest

[1] Grassi, B. The Reproduction and Metamorphosis of the Common Eel (*Anguilla vulgaris*), Q. J. M. S., vol. 39, page 371.
Grassi, B., and Calandruccio, S.
a. Ulteriori ricerche sulle metamorfosi dei Murenoidi. Rend. Acc. Lincei, VI, p. 43.
b. Descrizione d' un Leptocephalus brevirostris in via di trasformarsi in Anguilla vulgaris. L. C. pp. 239, 240 (Translation in Nature, LVI, p. 85).
c. Reproduzione e metamorfosi della Anguille. Giorn. Ital. Pesca e Acqui., 1887, Nos. 7, 8. (Abstract in Monit. Zool. Ital., VIII, pp. 233 and 234.)

length which the larva can attain in a given species, and the amount of diminution which accompanies metamorphosis, there are great individual variations.

Grassi assumes that three vertebræ develop to correspond to the first four protovertebræ and one for each following protovertebra. He "ascertained in an absolute manner that during the metamorphosis of the Murænoids the number neither of the myomeres, nor of the vertebral arches, nor of the spinal ganglia, is subjected to any change." He referred the following Leptocephali to their respective species:

Leptocephalus brevirostris	Anguilla vulgaris.
Leptocephalus stenops (in part), morrisii, punctatus	Conger vulgaris.
Leptocephalus hæckeli, yarreli, bibroni, gegenbauri, kölikeri, stenops (in part)	Congromuræna mystax.
Leptocephalus tænia, inornatus, diaphanus	Congromuræna balearica.
Leptocephalus kefersteini	Numerous species of Ophichthys.
Leptocephalus longirostris and Hyoprorus messanensis	Nettastoma melanuruni.
Leptocephalus oxyrhynchus	Saurenchelys cancrivora.

The eggs described by Raffaele have all the characteristics of pelagic eggs, and the one to be described here, which is very closely related to No. 6 of Raffaele, is certainly a typical pelagic egg. Grassi also secured the eggs of eels on the surface at Naples. Why, under the circumstances, he concludes that "they remain at great depths in the sea, and only exceptionally, for unknown reasons, some of them mount to the surface" is not apparent. Being lighter than sea water, having oil-spheres, and being in all respects typical pelagic eggs found on the surface, we must conclude that "if fertilization takes place at great depths" it must be "only exceptionally, for unknown reasons," that they remain at the great depths. The fact that Raffaele never secured eggs younger than when the gastrula was well formed would favor the supposition that they were fertilized at a great depth and rose slowly in the water.

Cunningham's interesting observations on the conger eel, if they are generally true for eels, would account for the fact that ripe females are rarely taken, and those of Schmidtlein and Hermes point against the supposition of Grassi that the females of eels in general ripen only at depths of at least 500 meters.

Schmidtlein[1] and Hermes[2] both noted that female conger eels sometimes died in confinement, the result of excessive development of ovaries which were not emptied.

In 1888 Cunningham[3] wrote:

> No one has yet, I believe, seen the fertilized egg of either the eel or the conger, although the ovaries and testes have been recognized and described.

He had not at that time found a male conger. In a later paper[4] he gives a general résumé of the work done on the conger. He himself found a perfectly ripe male 45 cm. long on December 13. Its eyes were strikingly prominent and its mouth short and broad. On December 19, among 9 congers caught, one 48 cm. and one

[1] Schmidtlein, R.
Beobachtungen über Trächtigkeits- und Eiablage-Perioden verschiedner Seethiere. Mitth. aus der zool. Station zu Neapel. I, p. 135, 1879. (Young conger eels scarcely 3 cm. long are captured in the middle of April.)
Beobachtungen über die Lebensweise einiger Seethiere innerhalb der Aquarien der zoologischen Station. Mitth. aus der zool. Station zu Neapel. I, p. 492. (Ripe female conger eels sometimes come to the surface and die from the presence of excessive numbers of ripe eggs, which for unknown reasons are not expelled.)

[2] Hermes, Otto.
Zoologischer Anzeiger, vol. IV, 1881.
The Propagation of the Eel. Rept. United States Fish Commission, 1879, pp. 457–463, 1882. Translated from circular No. 6, November 25, 1880, of the Deutscher Fischerei-Verein.
The Migration of Eels. Rept. United States Fish Commission, 1884, p. 1123, 1888.

[3] The Breeding of the Conger. Journ. M. B. A., old series, No. 2, p. 245, 1888.

[4] On the Reproduction and Development of the Conger. Journ. M. B. A., new series, II, p. 16, 1891.

66 cm. were males. The sexes can be detected by the following constant secondary sexual characters: The head in the female from above appears triangular, in the male the snout is distinctly blunter. In the female the snout is rounded in transection, in the male the surfaces of the snout are flat.[1] During December, January, and February Cunningham collected 8 male congers. The largest female conger ceased to feed in March. On July 24 a few eggs were obtained by squeezing. These contained no oil-spheres and sank in water with a density of 1.027. The diameter of one after the formation of the perivitelline space was 1.6 mm. This female died on September 10. Her ovaries weighed 7 pounds 5 ounces. The "ovaries increase very much in size and weight during the fasting period at the expense of the rest of the body, while in the total weight of the fish a great reduction takes place. Each conger eel breeds only once in a lifetime." He calculated the eggs in another female to be 7,925,280. Out of a total number of 34 congers 11 were males and 23 were females. That no ripe congers are caught is because they do not feed for weeks before becoming ripe.

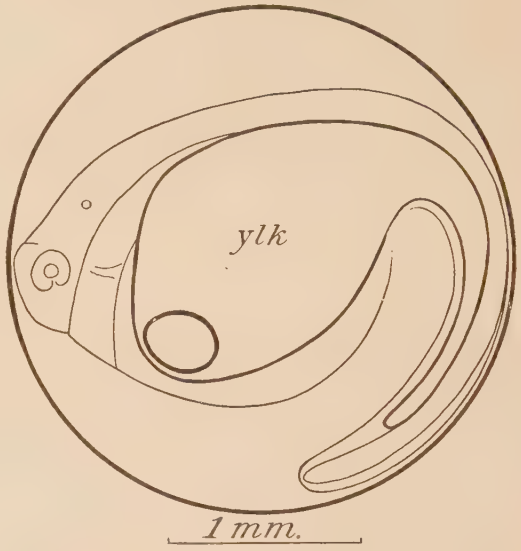


FIG. 1.—Outline of embryo, showing position in membrane and shape of the yolk. August 1.

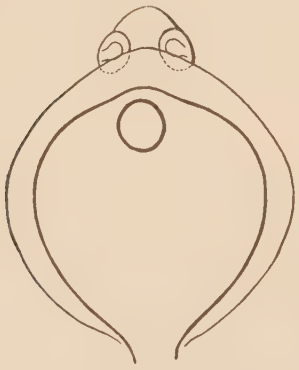


FIG. 2.—Outline of enlarged part of the yolk and yolk-sac of an embryo of the same age as fig. 1, from below.

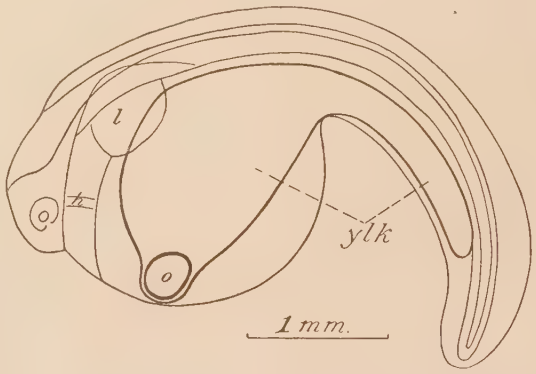


FIG. 3.—Embryo freed from its membrane, showing beginning of the constriction of yolk at its anterior end. August 1.

The eggs secured by Dr. Sargent measure 2.4 to 2.75 mm. from membrane to membrane.[2] The yolk, as in the eggs described by Raffaele, is made up of trans-

[1] In Nineteenth Report of the Commission of Fisheries of New York, page 280, Bean describes 5 male eels. It is very probable from Grassi's observations that these were the males of the common eel in their nuptial dress.

[2] Among other eggs collected by Dr. Sargent and preserved in formalin were six with many of the characters of eel eggs. They were large, with a very large perivitelline space, the yolk in spheres and with one large and a number of smaller oil-spheres. These eggs were notably larger than those brought home alive. They measure 3 mm. from membrane to membrane; the yolk measures 1.75 mm. or a little more. It is possible that these are identical with those to be described. The germ lies at one side of the egg, the oil-sphere at the other.

parent spheres not unlike those of the eggs of certain clupeoids. There are present, from one to six light-yellow oil-spheres of variable size. If more than one are present, then one is always much larger than any of the others. The yolk measures 1.75 to 2 mm. Some of the young were found to be hatched on the morning of August 3.

FIG. 4.—Embryo freed from its membrane, showing continued constriction of anterior end of yolk and general diminution of the enlarged anterior portion of yolk with the corresponding increase of caudal portion of yolk. August 2, 7.30 a. m.

Since many of these developed gaping jaws and some others, which did not hatch till several days later, developed normally, it is possible that the early hatching was not normal. Raffaele's eggs hatched in five or six days. He was able to keep them four or five days after hatching. For some time after hatching the larvæ floated with their heads upward—the probable result of the location of the oil-spheres. On August 6 they had assumed a normal horizontal position and the characteristic eel-like progression, but the pectorals were not yet used in swimming. Later they were seen eeling their way through the water, not infrequently nosing about the bottom and voraciously seizing anything that came in their way.

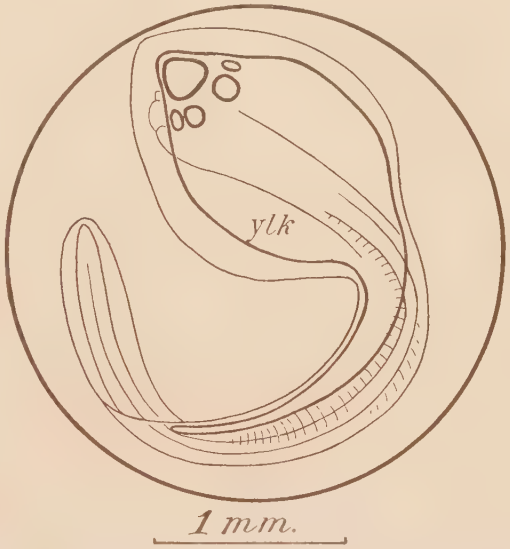


FIG. 5.—An embryo, of the same stage as Fig. 4, in its membrane, from below.

The characteristic feature of the eggs at the time I began to observe them, August 1, was the shape of the yolk. The bulk of this occupied the usual position, but a narrow stalk extended back below the alimentary canal. The oil-sphere or spheres occupied the extreme anterior part of the yolk [1] (figs. 1 and 2). The further history of the yolk in this species is unique among fishes and not sufficiently emphasized by Raffaele. In fig. 3 it is seen that the yolk is no longer rounded anteriorly, but that it ends in a marked protuberance and that the oil-sphere lies in this. The general mass of the yolk still retains the original shape and distribution. The anterior protuberance now becomes longer and at the same time narrower, so that the oil-sphere loses its rotundity and becomes elongate (fig. 4). At the same time the general mass of the

[1] All drawings were made from living specimens, or such as had just been killed by formalin. In the drawings, *al*, alimentary canal; *fv*, fourth ventricle; *ylk*, yolk; *l*, liver; *h*, heart; *o*, oil-spheres.

yolk diminishes rapidly in the yolk-sac, while in the elongated pouch along the ventral side of the alimentary canal no diminution is evident. On the contrary, there is an apparent increase; the entire yolk-sac becomes notably longer with the increase in the length of the body. Very soon (figs. 6 and 7) the oil-spheres, much elongated, with a small surrounding mass, are all that remains as a spindle-shaped figure (fig. 6) in the yolk-sac.

The yolk-sac does not at once lose its shape and bulk, but serves as an unusually large pericardial chamber which is equaled only in the practically yolkless *Cymatogaster*. On August 5 the yolk along the alimentary canal had suffered little diminution, and its outlines were quite regular (figs. 8 and 9). On August 6 this part of the yolk had become constricted in places, the outlines being less regular (fig. 10). The yolk had become yellowish in color and more fluid than vesicular. On the following day the constriction had deepened, and on August 11 the remains of the yolk were located in a series of minute globule more or less widely separated from each other. Long before this condition was reached, about August 8, the larvæ were taking food.

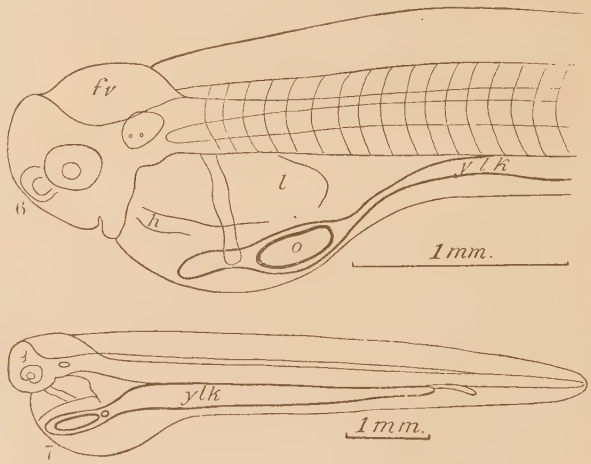


FIG. 6.—Head and anterior part of body, showing the continued reduction of the yolk and the very large fourth ventricle. August 3.
FIG. 7.—Outline of a larva somewhat older than that of fig. 6.

The number of segments developed in front of the anus differs slightly, ranging from 65 to 71. The number beyond this point could not be determined exactly. The

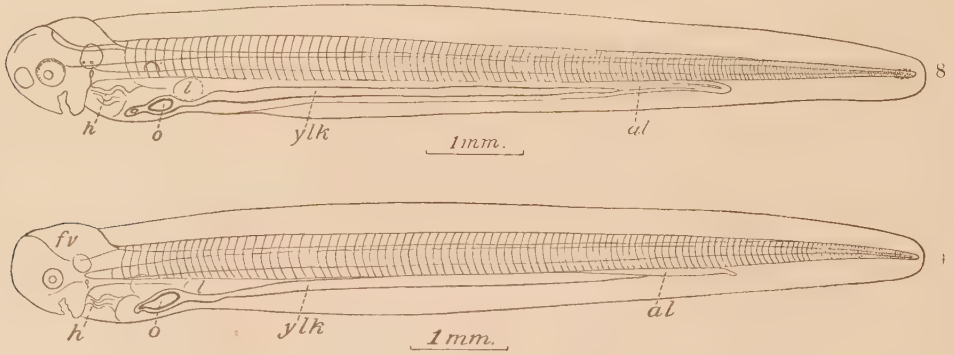


FIG. 8.—A larva on August 4. FIG. 9.—A larva on August 5.

notochord consists in its anterior fourth of single segments (fig. 11). In its middle region the segments do not extend through its entire thickness, but in the tail it is again formed of single segments. The lines separating these are so much more conspicuous than the lines separating successive myotomes that it is impossible to

make out the latter in the thin transparent tail of living specimens. The segments represented in the last half of the tail in fig. 10 are therefore not at all reliable.

Color is late in making its appearance. It is first evident at the end of the tail. At 6 p. m. on August 5 some of the larvæ had the following six spots above the alimentary canal and along lower margin of the myotomes of the tail: (1) About

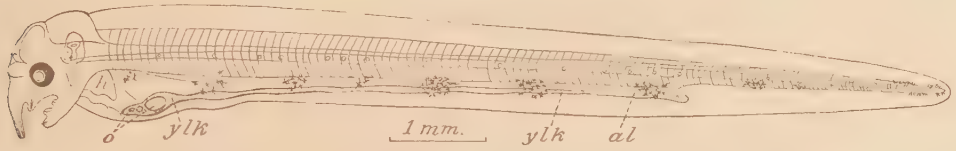


FIG. 10.—A larva on August 6; the mouth probably slightly abnormal.

middle of yolk; (2) halfway between this and end of yolk; (3) at end of yolk; (4) in front of anus; (5) some distance behind anus; (6) about the tip of the tail. The location of the spots coincides roughly with the moniliform enlargements of the abdominal yolk. Other spots are added between these already formed. The relative and actual size of the spots differ greatly, but the number is the same in different specimens of the same age. In the oldest larvæ the spots represented in fig. 14 were developed. Aside from those along the lower part of the sides there were a few cells on the upper jaw, and the scattered cells seen near the tip of the lower jaw as early as August 7 (fig. 12) have developed into a well-marked spot. The character of the pigment about the tail is also noteworthy. In the last stage figured the processes of the cells show a tendency to lie parallel to the embryonic fin rays. Pigment is formed in the eye with its earliest appearance on the body. No color, aside from the black pigment spots and the yellowish yolk, is seen anywhere about the larva during the time the larvæ were under observation.

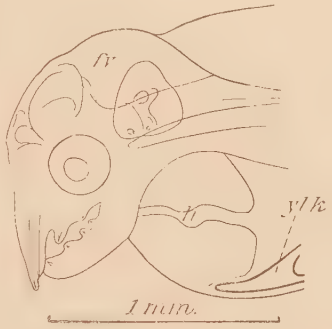


FIG. 11.—Head of larva of the same age as that of fig. 10, the mouth normal.

The fin fold is well developed, reaching from the nape around the tail to the yolk-sac. It is much wider along the back and in the region of the vent than about the tip of the tail or the ventral line of anterior abdomen. No rays had appeared in the oldest larvæ observed except about the tail, where there appears a distinct radiation.

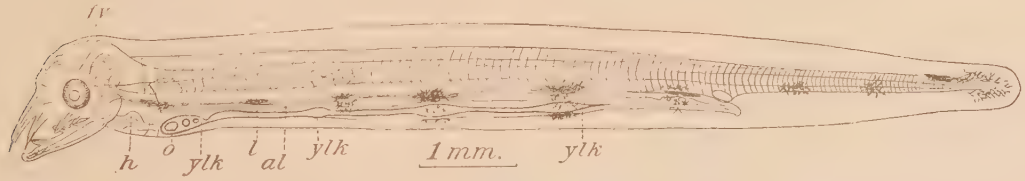


FIG. 12.—A larva on August 7.

The enormous development of the posterior half of the fourth ventricle is similar to the condition figured by Raffaele. In all but the last stage figured this part of the fourth ventricle is a large thin-roofed vesicle, separated from the fin fold in the earlier

stages by a distinct notch (figs. 6, 7, 8, 9, 10, 11). The auditory capsules are conspicuous, and, viewed from above, are seen to protrude from sides of head (fig. 13).

The alimentary canal is marked (1) by large fang-like teeth, (2) the early vesicular development of the liver, (3) the position of the anus near the body and remote from the margin of the ventral fin fold. As soon as the mouth is open, about the fourth or fifth day from the beginning of development, the margins of the jaws are seen to be marked by small protuberances. These are the swellings within which the teeth are developing. In the upper jaw four pairs of teeth are developed, graded from in front back, the anterior ones being comparatively enormous fangs. In the lower jaw four pairs are also developed. These are more uniform in size, but with the second one larger than the rest. In the oldest individual there were five pairs of teeth in the lower jaw. I am unable to say whether this was a normal condition. The teeth of the upper jaw close over those of the lower jaw.

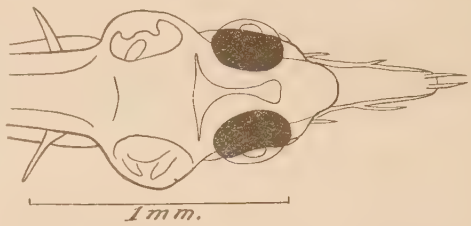


FIG. 13.—The head of a larva of August 7, from above.

FIG. 14.—A larva of August 4. The fin fold of this larva is probably represented as too low.

The œsophageal pouch of Raffaele has been mentioned. Even before hatching, it is a conspicuous pouch behind the heart. Later, when the anterior yolk has been largely consumed and is separated from the posterior yolk by a constriction, the vesicular structure becomes converted into a lobulated organ about this constriction.

The evidence that the eggs here described are those of *Leptocephalus conger* is circumstantial rather than positive. There are two eels found in this region—the conger and the common eel. The common eel egg has been identified as one without an oil-sphere. This would leave the conger as the only possible parent of the present species. The conger was abundantly taken on the trawl at the bottom over which these eggs were secured. On the other hand, the ripe conger egg has not been described, in spite of the fact that Hermes and Schmidtlein have both seen it. The egg of the conger described by Cunningham was obviously not ripe. The present eggs may provisionally be identified as those of the conger.

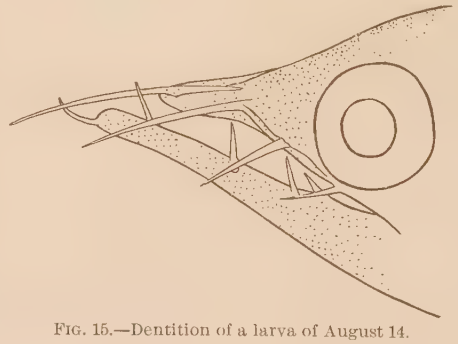


FIG. 15.—Dentition of a larva of August 14.

Contributions from the Biological Laboratory of the U. S. Fish Commission,
Woods Hole, Massachusetts.

INVESTIGATIONS INTO THE HISTORY OF THE YOUNG SQUETEAGUE.

By CARL H. EIGENMANN,
Professor of Zoology, University of Indiana.

In July, 1900, I was instructed by the U. S. Commission of Fish and Fisheries to make certain studies of the squeteague, in accordance with the following:

The Commission desires that you take up the study of the young squeteague (*Cynoscion regalis*) which is found schooling in Buzzards Bay, Narragansett Bay, and other waters of southern New England. As the squeteague is one of the most important food-fishes of this region, a more thorough knowledge of the young is very much needed. The following topics are suggested for your consideration: Habits; physical and biological surroundings; food; enemies; diseases; sexual conditions; rate of growth; changes in appearance incident to growth; length of sojourn in local waters; movements preceding and attending departure; route of migration, etc.

I herewith present my report on the work done during July, August, and September of 1900. I take pleasure in acknowledging my indebtedness to the director of the Woods Hole laboratory, Dr. H. C. Bumpus. Mr. Vinal N. Edwards, the collector of the station, has in most cases selected the site for making examinations, and, owing to his long experience, his advice has always been of great value. I am indebted to him for his ever-ready assistance.

I have not been able to approach a solution on the following topics:

(1) The diseases of the young squeteague, if it has any, are not known. The Peridinium which is destructive to the adult is probably also destructive to the young. The appearance of the Peridinium is periodic, with long intervals between. After the young leave the shallow water they are probably subject to the same enemies that the young of all fish are subject to, viz, adult squeteague and blue-fish.

(2) The line of migration has not been even remotely established.

DISTRIBUTION OF YOUNG SQUETEAGUE.

During the early period covered by this report, the latter half of July and August, 1900, the only location where young squeteague were found in Buzzards Bay was in the extreme upper parts, near Wareham. Mr. Edwards states that this is the only place where he has secured them during corresponding periods in previous years. In the region mentioned they were found in loose schools,[1] with occasionally stray individuals. Only occasionally a single individual was found in a haul of the

[1] The following record of catches near Wareham may be of interest as bearing on the matter of schooling:
July 25. First haul, about 100; second haul, about 25, made alongside the first.
Aug. 2. First haul, 7; succeeding hauls, none.
Aug. 9. First haul, 1; second haul, 6; third haul, none; made side by side.
Aug. 22. Three specimens in one haul, none in six other hauls.

seine. Usually, if any were caught at all, there were several or many individuals, the maximum being about 100. They were much more abundant at Wareham in the earlier part of the season than at the latter part, in the proportion of about 40 to 1. They were also found at Fields Point, Indian Point, and in Seekonk River at Providence. No further collections were made in Narragansett Bay. The young appear at the lower end of Buzzards Bay during September and October.

On September 9, 1893, several young squeteague, from 80 to 100 mm. long, were taken in Hadley Harbor and are preserved in the U. S. Fish Commission Museum at Woods Hole. On September 7, 1900, a single young specimen was taken in the Fish Commission trap on the Vineyard side of Nonamesset, near the gut separating Nonamesset from Naushon. Mr. Edwards states that occasionally they are found in Quissett Harbor during the latter part of the summer, but none was found at Quissett Harbor, Hadley Harbor, or at the Breakwater during 1900.* The line and rate of migration could not be determined from the few data secured. The one specimen caught in the trap was just large enough to be held by the meshes. Any smaller ones that may have gotten in are not available for record.

GENERAL HABITS.

Over 20 young were put into an aquarium, where they could be watched without disturbing them. They were entirely pelagic, never being found either at the bottom or at the top of the water. They kept together in a loose school, but without any definite coordination of the individuals of the school, either when they were undisturbed or when disturbed.

PHYSICAL AND BIOLOGICAL SURROUNDINGS OF YOUNG SQUETEAGUE.

The examination was limited to drawing a 150-foot seine, which enabled me to determine their distribution in a limited area about the shore. They were found here during July and August in water with a low specific gravity. They were most abundant in floating weeds and other places where shrimp were abundant. They were found most plentifully when it was scarcely possible to draw in the net on account of the masses of floating weeds. Their associates were almost invariably young eels, silversides, puffers, sea-robins, tautog, cunners, minnows, hog-chokers, scup, and king-fish, and occasionally toad-fish, bill-fish, various flounders, alewives, menhaden, sea bass, and young dog-fish. A direct connection of only two of these with the squeteague was established, i. e., the silversides and alewives, which serve the squeteague as food.

FOOD.

The food of the young squeteague consists exclusively of shrimp and young fish. In young individuals, 43 mm. long, the contents of the stomach made about 4 per cent of the total weight. The proportion of the shrimp and fish making up the food may be gathered from the following—it should be borne in mind that the stomach is usually full:

Of 14 specimens, with an average length of 60 mm., 9 contained shrimp only, 5 contained shrimp and young fish. One specimen, 55 mm. long, contained a silverside 28 mm. long. In another, the fish in the stomach was a clupeoid, probably an alewife. The other fish found in the stomach defied identification.

*Young squeteague were abundant at New Bedford on October 5, 1900.

Of 7 specimens, with an average length of 89.5 mm., 4 contained shrimp, 2 contained débris of fish, and 1 was empty.

Of 3 specimens, with an average length of 117 mm., all contained shrimp and fish, the latter in excess of the former.

The details of the food of 6 small specimens from Providence may be given here:

No. of specimen.	Length of specimen.	Stomach contents.
	mm.	
1	33	Fragments of 8 small shrimp.
2	33	Fragments of 11 shrimp (heads with eye-stalks forming the basis of the count); 3 silversides, longest 11 mm.
3	45	13 shrimp, 3 silversides.
4	61	7 shrimp, 1 fish.
5	47	4 shrimp.
6	45	10 shrimp.

Observations on those in the tank showed that they would readily take chopped fish dropping through the water, but not after it had reached the bottom. They are exclusively pelagic, and in nature confine themselves entirely to living or moving food. Even such unsatisfactory creatures as sticklebacks were taken by those in confinement.

RATE OF GROWTH.

The rate of growth during the period of observation is practically uniform, the young doubling their length in about thirty days. The details may be gathered from the accompanying table which gives the rate of growth of this species and also of some of the constant associates in the same water:

Date.	Squeteague.	King-fish.	Swell-fish.	Scup.	Bill-fish.	Sea bass.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
July 12	..... *c*	*a* 32.6	.....	.....	.....	.....
July 25	59.5	68.2	29	45	123	*b* 25
Aug. 2	79.5	79	35.6	58	155	.....
Aug. 9	89.5	107	.....	.....	.....	.....
Aug. 22	117	123	63	.....	.....	67
Sept. 7	*c* 200	.....	.....	.....	.....	.....
Sept. 15	.....	.....	.....	.....	.....	*d* 76
Sept. 20	*e* 92.5	.....	.....	.....	.....	.....
Oct. 5	*f* 180	.....	.....	.....	.....	.....

a 1899. Based on 11 specimens ranging from 28 to 30 mm.
b July 24, 1899. Based on 9 specimens ranging from 23 to 26 mm.
c One specimen, probably much above the average; 6 in collection at Woods Hole, taken in Hadley Harbor Sept. 9, 1893, range from 80 to 100 mm., and average 91 mm. in length.
d Based on 3 specimens ranging from 73 to 82 mm.
e Based on 4 specimens from Seekonk River, 70, 85, 95, and 120 mm. long, respectively.
f On October 5 Mr. Edwards found young squeteague 6 to 8 inches long quite abundant in New Bedford River. Many were caught off the wharf with hook and line by fishing on the bottom. No definite measurements were recorded.

At the rate of growth indicated here, the size of many adults (400 mm.) sent to the market would be reached in about seven months, but the rate of growth in length very probably decreases with age. Nevertheless, it seems very probable that the fish reaches marketable size in about a year from birth.

The specimens collected in Narragansett Bay were much smaller than those of Buzzards Bay of the same date; 41.9 mm. in Narragansett Bay on August 3 and 4; 79.5 in Buzzards Bay on August 2. If the rate of growth is uniform, the Narragansett specimens are eighteen days younger than the Buzzards Bay specimens.

CHANGES WITH AGE.

The young of the fish differs so strikingly from the adult that it would readily be referred to another species or genus. The more striking changes with age occur in the relation of depth to length, in the relative size of the eye, in the color, and in the shape of the caudal fin. The smallest secured came from the head of Narragansett Bay; it is 25 mm. long to the base of the caudal. The greatest depth is below the

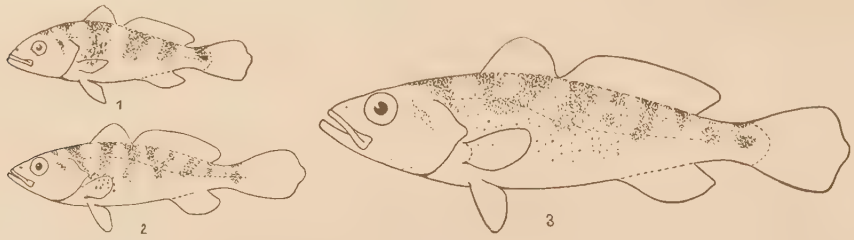


FIG. 1.—Smallest specimen, 32 mm. long, Indian Point, July 5, 1900, showing color pattern in deeper layer of skin.
FIG. 2.—Specimen 41 mm. long, Indian Point, July 5, 1900, showing color pattern. Color entirely in deeper layer of skin.
FIG. 3.—Specimen 70 mm. long, Indian Point, July 5, 1900, showing addition of color cells between those grouped into bars.

FIG. 1.—The left side of a specimen 95 mm. long, Wareham, August 9, showing indistinct bars and oblique streaks.
FIG. 2.—The right side of the same specimen with the outer skin removed and showing the bars made less distinct than in younger specimens by the appearance of numerous color cells between them. No evidence of oblique streaking, which is entirely due to color cells in the outer layer of the skin. The blood vessels are surrounded by pigment cells and show as black lines.

first dorsal spine and measures 8 mm. The average depth in 10 individuals from the same place, with an average length of 29.2 mm., is 8.7 mm., or 29.4 per cent of the length. The average width is 4 mm., or 13.7 per cent.

In 7 specimens from the same place, taken at the same time, ranging from 46 to 60 mm., and with an average length of 50.6 mm., the depth averages 13.14 mm., or 25.96 per cent; the width 5.71 mm., or 11.08 per cent. In 3 specimens from

Wareham, taken August 22, averaging 97 mm., the depth averages 26 mm., or 26.8 per cent. The average width is 13 mm., or 13.41 per cent.

In 1 specimen, 170 mm. to base of caudal, the depth is 40 mm.

In 2 adult specimens, 420 (415 and 425) mm. long to the base of the caudal, the depth measures 86.5 mm., or 20.59 per cent. The width at the axils averages 67 mm., or 15.95 per cent.

In 2 specimens, 50.6 mm. long to base of caudal, the depth is 113 mm.

The fish when adult are much more cylindrical than the young, which are compressed and elevated. In the adult the head is nearly conical, but little deeper than

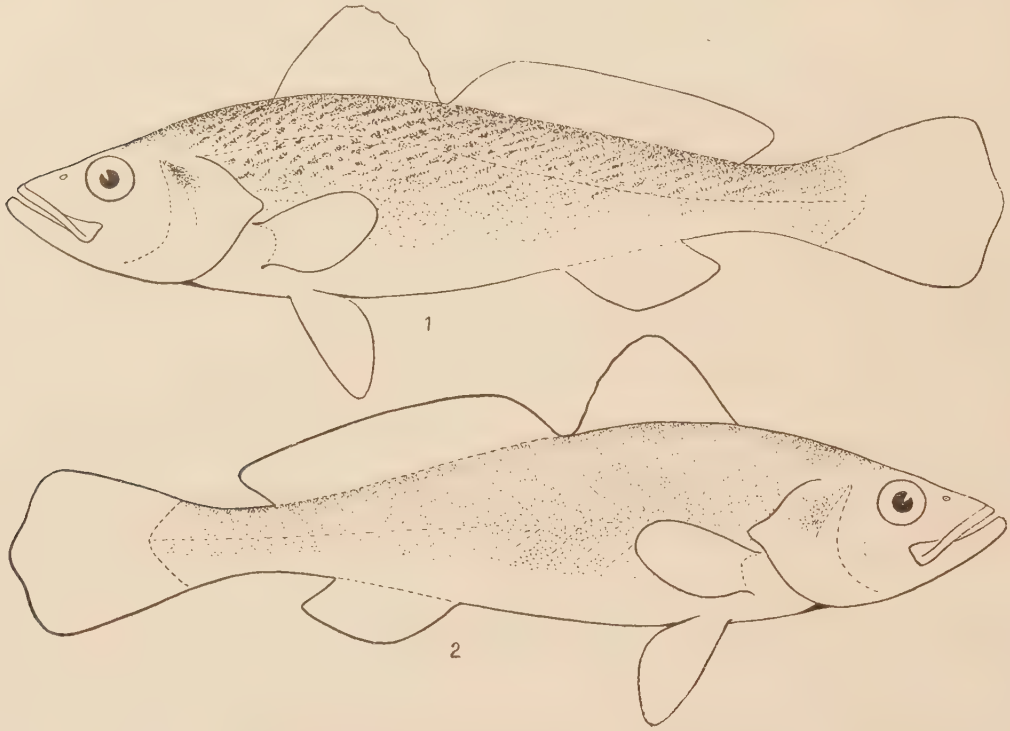
FIGS. 1 and 2.—The left and right sides respectively of a specimen 120 mm. long taken at Wareham, August 22. Fig. 1 represents the general color which is largely due to the color cells in the outer layer of the skin. The streaking which is conspicuous in the adult is here still obscured by the general distribution of pigment in the deeper layer shown in fig. 2, which represents the coloration of the right side after the removal of the outer skin.

high; in the young it is much deeper than high. The eye changes its relative proportions to the size of the head, as in other fishes. This is due to the fact that while the eye grows throughout life it does not grow in the same proportion as the rest of the fish.

Length of fish.	Length of eye.
	mm.
26 mm. to base of caudal	2.5
41 mm	4.5
108 mm	8
170 mm	11.5
415 mm	20
560 mm	22

A very marked change takes place in the shape of the caudal. In the adult the margin of the caudal is distinctly concave or lunate. In all stages of the young, on the other hand, the caudal rays between which the lateral line extends are the longer, the caudal being obtusely pointed, with 9 rays in the upper and 8 in the lower lobe. The upper lobe of the caudal is slightly lunate, while the rays of the lower lobe are graduated, and this lobe is rounded.

Very marked changes take place in the color with age. The changes occur largely in the sides of the body. The color pattern of the head changes little with age. There is here chiefly an addition of color cells to those already present in the



FIGS. 1 and 2.—The left and right sides, respectively, of a specimen 200 mm. long taken September 7, 1900, in the Commission's net in Vineyard Sound. The left side shows the characteristic markings of the adult which are due entirely to the color in the outer layer of the skin. The nearly uniform distribution of color in the deeper layer of the skin seen after removal of the outer skin is represented in Fig. 2. This deeper layer of color no longer enters into the general coloration owing to the formation of connective tissue between it and the outer layer.

smallest specimens. In the smallest specimen there is a series of four pigmented bands, extending across the back. The first at the spinous dorsal, the second at the beginning of the soft dorsal, the third some distance in front of the end of the soft dorsal, and the last across the caudal peduncle. All of these extend but little beyond the lateral line. Their margins correspond roughly with the margins of myotomes. At the dorsal angle of the myotomes the bands are usually bent, but without regularity. In the specimen under discussion, those on the left side are shifted backward, at this point, of those on the right side; two are continued straight down, one is shoved forward and the other backward. The region between the bands is not free

from pigment, but the cells are here smaller and contracted. A line of cells extends along the base of the anal and to the tail. The spinous dorsal is largely black; the soft dorsal and caudal have pigment cells along the membrane. All the chromatophores at this stage are in the deeper layers of the dermis below the scales.

With an increase of a few millimeters in length additional bands are interpolated between those mentioned, first one between the two under the soft dorsal, then one below the end of the soft dorsal, and lastly one between the two dorsals. All of these are formed by the time the fish has reached a length of 44 mm. to the base of the caudal. Eventually the deeper layer becomes deeply pigmented through the appearance of chromatophores in the spaces between the bands. Numerous small chromatophores have also appeared in the superficial layer of the dermis, especially along the edge of the scales, so as to give a distinct black margin. With growth the chromatophores at the margin of the scales and those in the superficial layers of the dermis, as well as those on the fins, become very numerous. In specimens 75 mm. long to the base of caudal the bars are still faintly visible but the whole fish has taken on a dusky color on the sides, back, and fins, with a distinct black border to the dorsal and caudal.

In a specimen 110 mm. long the black margins of the fins are less conspicuous, the black edge of the scales has become obscure on account of the great multiplication of superficial pigment cells. The bars of the young stage are entirely obliterated and the superficial pigment shows the characteristic oblique streaking of the adult, but much less conspicuously than in the adult.

At this stage the color is due to the now uniform pigmentation of the deeper layers of the dermis blending with the streaked pigmentation of the superficial part of the dermis. With age the connective tissue between these two layers of pigment becomes so thick as to entirely eliminate the deeper pigment as a factor in the formation of the color pattern. The surface pigment, which is from the first laid down in streaks, alone gives value to the pattern in the adult.

The obvious differences of the sexes appear so late that I can only report on the sex relations that no sex differences are apparent at a length of about 100 mm.

Contributions from the Biological Laboratory of the U. S. Fish Commission,
Woods Hole, Massachusetts.

A NEW ISOPOD PARASITIC ON THE HERMIT CRAB.

By MILLETT T. THOMPSON.

While at Woods Hole, in the summer of 1897, studying the small hermit crab (*Pagurus longicarpus* Say), I found parasitic upon this crustacean a hitherto undescribed Bopyrid, allied to *Phryxus resupinatus* Müller, and apparently representing a new genus. About 1.5 per cent of the crabs at Great Harbor were thus infested (1898), and from 3 to 4 per cent of those at Hadley Harbor. A single specimen was taken at Edgartown in 1898, and another at Warwick, Rhode Island, in 1900. In the channels where there is a swift current the percentage of infested crabs is low, due probably to the more effectual dispersal of the free-swimming larvæ.

The female parasite occurs on the abdomen of the hermit, to which it is attached, back downward, by its mandibles and legs. The male is found on the posterior part of the marsupium of the female, usually lying to the right (apparent left) of the median line, the head directed anteriorly. The presence of the parasite does not effect any alteration in the case of the secondary sexual characters of its host. On the average the infested crabs seem quite as resistant to adverse conditions as the uninfested ones.

Stegophryxus hyptius, genus et species nov.

Adult Female (Plates 9 and 10).

Broad in proportion to length, marsupium very large, abdomen about half the length of thorax, distinct from it, 6-jointed, with five pair of triramous pleopoda and a pair of oval uropoda. Length, about 9.1 mm. Color, yellowish-white, opaque. Ovaries, when full of ripe eggs, orange-yellow.

Head (pl. 9, figs. 5 and 6), from the dorsal side appears as an oblong elevation ending anteriorly in a blunt lobe, which represents the median portion of the much-reduced front (*Fr*). As the lateral portions of the front are almost wholly obsolete, appearing only as two inconspicuous lobes, the greater part of the antennules, antennae, and tip of rostrum, is visible dorsally. The antennules are 3-jointed and consist of a large globose basal joint, surmounted by a small cylindrical second and a minute third joint; outer joints bristle-tipped. Each antenna (A_2) arises along the side of rostrum as a columnar ridge, whose distal end is visible dorsally (fig. 7, A_2). From this ridge a 4-jointed flagellum arises, its proximal joint stout, the three distal joints slender; all the joints bristle-tipped. Ventral surface of head broader than dorsal surface and sharply elevated at posterior border, giving a strong antero-dorsal slope so that the erect hypopharynx points almost anteriorly. At sides of posterior border three curved processes arise (fig. 7, *Pro*), and in the midline are two thin foliaceous plates (fig. 7, *Fp*). Rostrum conical. Mandibles (*Mnd*) slender, with expanded tips, the edges of which are incurved so that, pressed together, they form a sucking-tube. Near the bases of mandibles appear the oval maxillulæ (Mx_1). Hypopharynx (fig. 7) erect, highly keeled, and plays no part in formation of rostrum. Maxillipeds (fig. 5) large; each consists of a foliaceous anterior and a somewhat thicker posterior blade; during life these organs keep up a rapid fanning motion. There is no trace of a palpus.

The thorax (pl. 9) is concealed ventrally by an enormous marsupium, built up of five pairs of

thin brood-plates, each strengthened by a median chitinous rod. The posterior or fifth pair (fig. 4, Bp_5) lie externally to the others and form the major part of marsupium; they are attached along the border of fifth and sixth thoracic segments. The posterior angle of each forms a shallow pouch (fig. 4, *Po*). Nearly concealed by these plates, and almost closing the marsupium anteriorly, are the third and fourth pairs of plates, similar to each other in shape (fig. 2, Bp_3) and having an oval ventral and a rounded dorsal portion (fig. 3, Dbp_3 and Dbp_4). This dorsal part conceals the legs of the parasite. The second pair of plates are oblong and are hidden under the others (fig. 2, Bp_2). The first pair consists of a rather oval anterior and a triangular posterior blade. The latter (fig. 2, Pbp_1) is strengthened along its outer (longest) border and across its base by a chitinous rod. The anterior blades (fig. 2, Abp_1), in company with the dorsal portions of the third pair of plates, form the funnel-like anterior end of the marsupium.

The details of the thoracic segments are shown in fig. 3. The first five are crowded together, their fleshy lateral portions strongly bent toward the head. The lateral parts of first four segments end in a small roughened boss or cushion, on which the roughened third joint of the pereiopod impinges. This cushion (*Cu*) may represent a modified epimeron. Internally to this cushion is a flat shield-shaped area which comes in contact with the abdomen of the host (fig. 6, *Sh*). The lateral portions of fifth segment end in a sharp crest, and there is no "shield." The sixth segment is very long; it narrows posteriorly, has a fleshy median keel and only slightly developed lateral portions. The seventh segment is short, fleshy, about as wide as sixth and similar to it except that it is not keeled. Ventral surface of thoracic segment fleshy, posterior borders of sixth and seventh modified into complex elevated keels (fig. 8). (In the plate it will be noted that the first serrated keel belongs to segment 6, the second to segment 7, the third (*X*) to the first abdominal segment.) Pereiopoda of the sixth and seventh segments are alike and quite simple in construction (pl. 10, fig. 7); those of the other five segments are modified, the last three joints being twisted to one side (pl. 10, fig. 6). Extensor muscles enormously developed.

The abdomen (pl. 9) consists of six fleshy segments, five of which bear a pair of pleopoda. Each pleopod has three oval blades arising from a short common base. Two of these are subequal and extend in a lateral direction; the third is smaller and points ventrally. This ventral ramus is broadly expanded in the pleopoda of the first abdominal segment, especially on the right side (fig. 4, Vpl_1). The first segment has ventral keels, similar to those on the last thoracic segments. Between the oval uropoda of the sixth segment (*Ur*) is a minute conical prominence.

Description of Adult Male. (Plate 10.)

Three and two-thirds longer than broad. Abdomen unsegmented, about a third of entire length. Color dull yellowish. Around the heart in the abdomen is an orange-colored area and a narrow streak of same color runs forward along the mid-dorsal line. Sometimes splashes of black occur on the sides of the head and thorax. Length about 3 mm.

Head (pl. 10, figs. 1 and 2) oval, elevated in center, the margin entire and not inflexed. Eyes minute (fig. 1, *E*). On the under side is a shallow central depression, in front of which arise the short 3-jointed antennulæ (A_1). From the depression the 8-jointed antennæ (A_2) and the conical rostrum take their origin. First joint of antennæ elbowed, the others cylindrical, the distal ones bristle-tipped. Sixth, seventh, and eighth joints very small, together scarcely equaling the fifth in length. Rostrum prominent, built up dorsally by the labrum (*La*) and ventrally by the hypopharynx. Apex of latter conceals tips of mandibles and median part of labrum. Mandibles (*Md*) slender with thick bases and sharp chitinous tips. I have not found maxillulæ. Between the maxillæ, and extending forward from a transverse ridge, are the 3-jointed (?) maxillipeds (*Mxp*). The thorax consists of seven fleshy segments. It narrows slightly posteriorly and is moderately convex. Sides subparallel, somewhat deflexed, epimera not distinct. First segment notched for reception of head. Seven pairs of pereiopoda, whose structure and musculature can be understood by reference to the plate (pl. 10, fig. 8). Abdomen ovoid or sometimes pear-shaped, shows no signs of segmentation, and has no traces of appendages.

Description of Immature Forms.

I. The development of the youngest female specimen taken (pl. 10, figs. 9 and 10) was a little more advanced than the stage which Giard has called the "phryxoid" stage. It may be termed the metaphryxoid stage. More slender than adult; nearly three times longer than broad. Lateral portions of the thorax distinct from and scarcely wider than median part. Marsupium present but

rudimentary. Abdomen as long as thorax. Length, 5 mm. Head short. Front (*Fr*) prominent, transverse, with a straight, entire, uninflexed margin, which conceals the mouth parts, antennules, and the basal joints of antennæ. Mouth parts much like those of adult, but the hypopharynx is flatter and less erect and the mandibles are stout and have sharp tips (*Md*). Inflexed border of labrum narrow, maxillipeds small and not inflated at base. They consist of an oblong-oval posterior and a smaller rounded anterior blade. No palpus. The rostrum points anteriorly, rather than, as in the adult, dorso-anteriorly. Thorax narrow and not quite as long as abdomen. Segments subequal, fleshy, with the median and lateral parts of nearly same width (fig. 9). Sixth and seventh segments narrower than the rest, distinct from them, and have only rudiments of ventral keels. Epimera (?) of thorax distinct (*Ep*), no "cushions" or "shields." Pereiopoda like those of adult. Brood-plates small and flat; those of third and fourth pairs are without dorsal portion, those of fifth pair lack pouches at posterior angles. The abdomen is like that of adult in form, except that the ventral rami of first pair of pleopoda are not expanded ($V pl_1$).

II. Three cryptoniscid-stage larvæ, probably males, were taken from the female just described. One was in the marsupium; the others were clinging to the appendages (pl. 10, figs. 3, 4, and 5). Abdomen proportionally longer than in adult and consisting of 6 segments. Pleopoda and uropoda present. Epimera distinct. Color white with black blotches. Length about 0.7 mm. Margin of head narrow, inflexed at sides and in front. Rostrum prominent. Antennules complex in structure and provided with long bristles (fig. 4, Ar_1). Antennæ 8-jointed and very long and slender. Thorax of 7 smooth segments, with distinct strongly deflexed epimera (*Ep*); 7 pairs of pereiopoda similar in form to those of adult, but more delicate and slender. The abdomen consists of 6 segments, is highly convex, the first 5 segments having deflexed epimera. Five pairs of flat biramous pleopoda (fig. 5), the blades standing with their faces at right angles to the long axis of body. Uropoda (fig. 3, *Ur*) biramous, consisting of a cylindrical protopodite, a cylindrical exopodite, and a shorter cylindrical endopodite. Each endopodite and exopodite bears one long bristle and a tuft of short hairs.

III (not figured). Several females, of a stage considerably more advanced than the one described above, were taken. In all cases they had a male of about 2 mm. in length, of adult form, clinging to them. Length varying from 6 mm. to 7 mm. Appearance much like fig. 9 of plate 10, but the whole thorax is wider. Lateral parts slightly broader than median portion. The head is adult in length, but the front is still rather wide, very fleshy, and trilobed, the lateral lobes being larger than the median. Tip of rostrum and distal portions of antennulæ and antennæ visible dorsally; otherwise the head and mouth parts are adult in structure. Thorax narrow and as long as abdomen. Dorsal segments fleshy, though less so than in preceding stage, and the first five segments have begun to crowd anteriorly. Sixth segment fleshy, not keeled, scarcely longer than fifth or seventh. Ventrally the transverse keels on sixth and seventh segments are rudimentary, but more developed than in metaphryxoid stage; marsupium larger, though the brood-plates are still quite rudimentary. Brood-plates of third and fourth pair have developed the dorsal portion; first pair nearly adult in shape, and the funnel under the head has begun to form. Tips of first brood-plates and maxillipeds are visible from dorsal side, much as in adult. The pereiopoda are adult in form, and "cushions" and "shields" are present. Abdomen like that of the metaphryxoid stage.

IV (not figured). One specimen of a female nearly mature was taken. In this the abdomen was nearly as long as the thorax, sixth thoracic segment not yet of adult proportions. Length, 10 mm.

As mentioned above, the nearest relative of this species is *Bopyrus* (*Phryxus*) *resupinatus* Müller, described in 1870 from a small hermit-crab at Desterro, South America. This parasite was attached, in its early larval stage at least, at the roots of *Succulina purpurea*, or less frequently *Peltogaster socialis*, both of which Cirripeds were extremely common on the hermit-crab mentioned, the name of which is not given. This is strikingly unlike the condition in regard to *Stegophryxus hyptius*, for I have never taken the latter in association with any other parasite. I have examined several thousand specimens of *Pagurus longicarpus* from the vicinity of Woods Hole, but have never found any external parasite other than the Bopyrid. The proportions and structure of body of the Desterro species are also different from those of *Hyptius*, as far as can be judged from the very imperfect knowledge of the anatomy of *resupinatus* at our disposal. Hence I consider the two forms to be distinct, though the likeness of the Woods Hole form to Müller's species suggested the name *hyptius* (*ὕπτιος=resupinatus*).

As will be noted, the male is similar to the male of *Athelges* (Hesse), *Pleurocrypta* (Hesse), and *Phryxus* (Räthke), and on this basis apparently some authors have grouped the species of these three genera under *Phryxus*. *Phryxus* thus defined will of course admit *hyptius* and *resupinatus*, but when we

consider how little is really known about these genera, and how dissimilar the females are, it seems better to retain them as distinct genera until detailed knowledge of the anatomy of the various species furnishes the basis for more accurate classification. Sars in his "Account of the Crustacea of Norway" has thus regarded them.

Hyptius is more closely allied to the members of *Athelges* than to those of either of the other genera, but its female presents characters, especially in the uropoda and pleopoda, which seem to prohibit its reference to that genus as defined at present. As writers on this family prefer to institute tentative or even undefined genera for new species where there is doubt as to their exact position, I suggest that *resupinatus* and *hyptius* be placed in the following tentative genus, having the characters given below as its probable limits.

STEGOPHRYXUS, nov. gen.

Male, abdomen ovoid, without appendages or traces of segmentation. Antennulæ 3-jointed, antennæ 8-jointed. Female, abdomen distinct from thorax, 6-jointed, with five pairs of triramous pleopoda and a pair of oval uropoda. Legs modified for clasping dorsalward. First five segments of thorax crowded anteriorly. Nearly symmetrical.

στεγειν=to roof or cover (in allusion to marsupium covering the parasite when on host).

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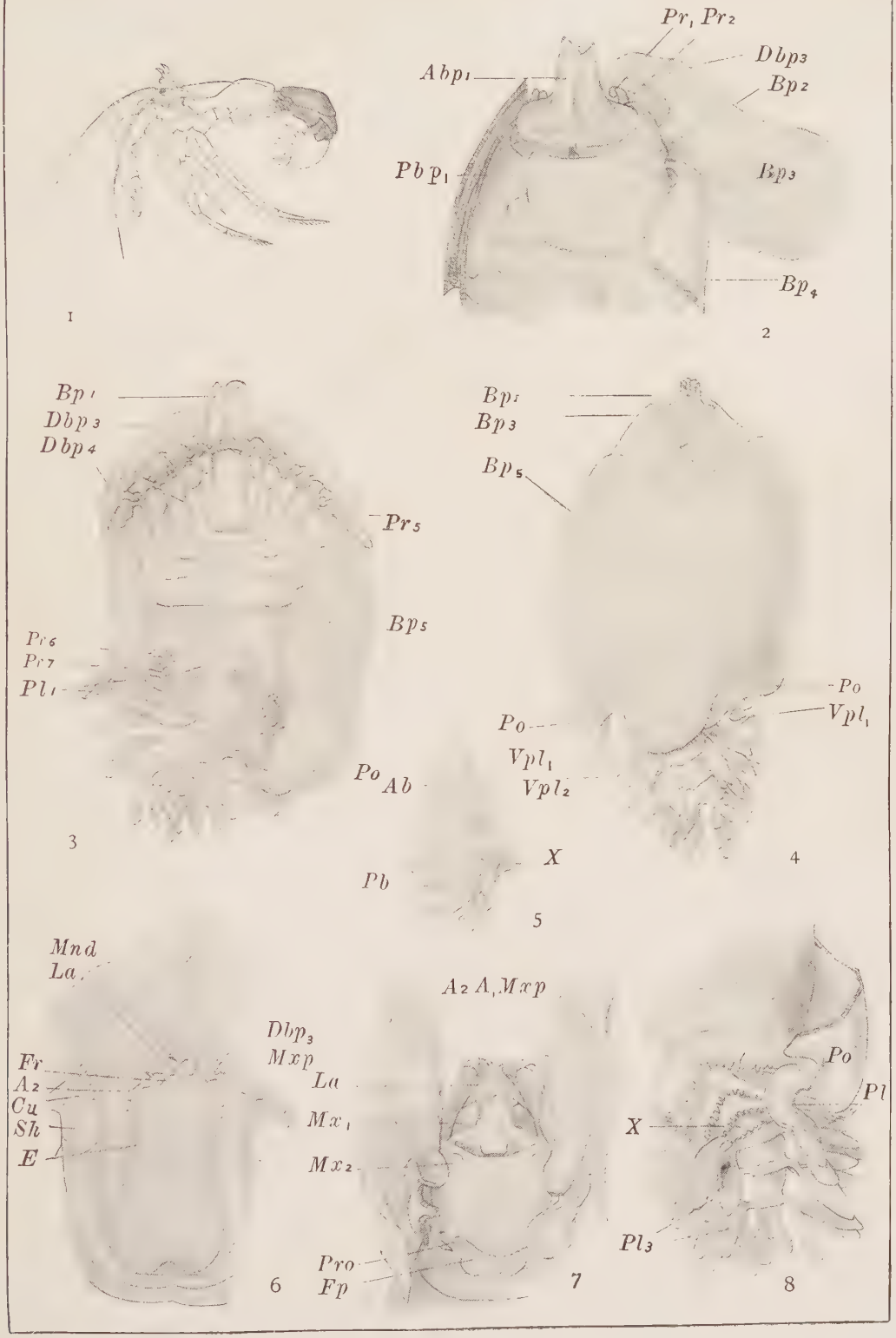
DESCRIPTION OF PLATES.

Plate 9.

Fig. 1. *Hermit crab with parasite attached.* Natural size.
2. *Anterior portion of adult female, ventral, somewhat diagrammatic.* On the right side, all the brood-plates except the first, and on the left the fourth (Bp_4) and fifth have been cut away. The third (Bp_3) is reflexed to show the second (Bp_2).) Abp_1, Pbp_1 = the anterior and posterior blades of first brood plates. Pr_1, Pr_2 = pereiopoda of first and second pairs, respectively. Dbp_3 = dorsal portion of the third brood plate.
3. *Adult female with marsupium distended with eggs. Dorsal.* ×8. Bp_1 = funnel formed by first brood-plates. Dbp_3, Dbp_4 = dorsal portions of third and fourth plates, respectively. Bp_5 = the distended fifth brood-plate with the pouch (Po) at its posterior angle. Pr_5, Pr_6, and Pr_7 = Pereiopoda of fifth, sixth, and seventh segments, respectively. Pl_1, Rami of first pleopod. Ur = Uropoda.
4. (The dotted outline shows the position occupied by the male.) *Adult female with empty marsupium. Ventral.* ×7. Bp_1, Bp_3, Bp_5 = brood plates of first, third, and fifth pairs, respectively. Po = pouch at angle of fifth pair. Vpl_1 = enlarged ventral ramus of the first pleopod. Vpl_2 = ventral ramus of second pleopod.
5. *Left maxilliped of adult female. Ventral (outer) surface.* ×15. Ab = anterior blade. Pb = posterior blade. X = point of attachment. (Two of the processes at the side of the head are shown.)
6. *Head of the adult female. Dorsal.* ×17. Fr = median part of front. Md = mandibles. La = dorsal part of labrum. Mxp = maxillipeds. Dbp_3 = dorsal part of third brood plate. A_2 = antenna. Cu = "cushion." Sh = "shield." E = eye.
7. *Head of adult female. Antero-ventral.* Free-hand. (The posterior brood plates are removed, and the first pair with the maxillipeds are reflexed to show the ventral surface of the head, etc. The base of the right maxilliped is cut away to show the processes at border of head (Pro).) A_1 = antennula. A_2 = ridge which forms the basal joint of the antenna. La = inflexed margins of labrum. Mx_1 = maxillula. Mx_2 = maxilla. Mxp = maxilliped. Fp = leaf-like platen at median posterior border of head.
8. *Abdomen and posterior part of thorax of the same. Ventral.* ×8. (All the brood plates except the pouch-like posterior angle (Po) of the fifth plate have been removed.) X = keel of the first abdominal segment (see page 54). Pl_1, Pl_3 = pleopoda of first and third segments, respectively.

Plate 10.

Fig. 1. *Adult male. Dorsal.* ×18. A_2 = Antenna. E = eye. Int = intestine. Ht = heart.
2. *The same. Under surface of head.* ×33. The right pereiopod has been removed; x marks its position. A_1 = antennules. La = the inflexed border of labrum. Md = basal portions of the mandibles, the median and apical parts being concealed by the labrum and hypopharynx. Mx_2 = maxilla. Mxp = maxillipeds.
3. *Cryptoniscid from young female. Lateral.* ×87 (?). A_1 = antennula. A_2 = antenna. Ep = epimeron of first thoracic segment. Ur = uropod. Pl = pleopoda.
4. *The same. Under surface of head.* ×165 (?). A_1 = Antennula. R = rostrum.
5. *The same. Pleopod of third abdominal segment.* ×105 (?). Ex = outer ramus. En = inner ramus.
6. *Adult female. Musculature (diagrammatic) of one of the first four thoracic pereiopoda. Lateral.* ×30. (From specimens cleared in cedar oil and from reconstructions.) Cu = "cushion." Sh = "shield." Bp = base of brood plate (mostly cut away). Ex = extensors.
7. *Adult female. Musculature (diagrammatic) of pereiopod of sixth or seventh segment. To show approach to the simpler male pereiopod. Lateral.* ×30. Ex = extensors.
8. *Adult male. Musculature of pereiopod. Lateral.* ×60. Ep = border of segment. Fl = flexors. Ex = extensors.
9. *Larval female (metaphryxoid stage). Dorsal.* ×18. (Only the thorax and part of the abdomen are shown; most of the pereiopoda are bent ventrally and are hidden by what may be the epimera (Ep).) Fr = front. A_2 = antennæ. E = eyes. Pr_7 = pereiopod of seventh pair. Pl_2 = pleopod of second pair.
10. *The same. Ventral.* ×10. (Showing the positions in which the three males (?) were found). ♂ = position of the one which was in the marsupium. Md = mandibles. A_1 = antennula. Bp_1, Bp_4, Bp_5 = brood plates of first, fourth, and fifth pairs. Pr_5 = pereiopod of fifth pair. Vpl_1 = ventral ramus of first pleopod. Ur = uropoda.



M. T. Thompson del.

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1. VIEW IN EAST HARBOR SWAMP.

2. SAND BEACH VEGETATION

3. LICHEN-GROWN ROCKS NEAR GIBRALTAR ISLAND.

4. ROCKY SHORE OF SOUTH BASS ISLAND.

5. SHORE OF SQUAW HARBOR, SHOWING NUPHAR IN THE FOREGROUND.

6. SANDY BEACH AT CEDAR POINT, OHIO.

THE PLANTS OF WESTERN LAKE ERIE, WITH OBSERVATIONS ON THEIR DISTRIBUTION.

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INTRODUCTORY.

In the spring of 1893 the writer accompanied a party sent out by the Michigan Fish Commission, under the direction of Prof. Jacob Reighard, to study the biology of the Great Lakes. The lake chosen for the study that year was St. Clair. This small lake presents in many respects ideal conditions for the study of lacustrine plant life. The extensive swamps and the gradually sloping mud bottom of its northwest side, which is also protected from the most violent winds, and therefore seldom experiences a heavy surf, provide an environment admirably suited to the growth of a variety of plants. The results of that year's work were published as the "Plants of Lake St. Clair,"[1] and is believed to be the first study of the kind undertaken in American lakes. It was therefore a pleasure to continue this line of work in Lake Erie. The United States Fish Commission, having entered upon a systematic investigation of the biology of the Great Lakes, placed the work under the direction of Professor Reighard, and the place chosen was Put-in Bay, Ohio. A United States fish-hatchery is located there, and the buildings and boats were placed at the disposal of the party.

The present paper covers the work on the Phanerogams, Characeæ, and Desmideæ. The work on the algæ, except Desmids, was in charge of Dr. Julia Snow, of Michigan University. The field work was done during the summer of 1898.

APPARATUS USED.

Much of the work was done from a row boat in Put-in Bay and in the swamps on the mainland, but the deeper parts of the lake were examined by means of an ocean dredge let out from the steamer *Shearwater*, while going at a low rate of speed.

The plankton and tow nets used in collecting the microscopic organisms have been described by Reighard.[2] For collecting the larger plants growing in water more than a foot or two deep a grapple was used (fig. B, page 58). This was made by passing four or five bent steel wires through a piece of 1.5-inch pipe and bending back the free ends to make hooks. The pipe was filled with lead to make it heavier

[1] Bulletin of the Michigan Fish Commission No. 2, 1894.
[2] Reighard, J. E. A biological examination of Lake St. Clair. Bull. Michigan Fish Commission, No. 4, 1894.

and a rope fastened through the loops of the wires. For taking soil samples an instrument was made after drawings in Delbecque, "Les Lacs Français" (fig. A). This gave satisfaction in soft bottom, but when the clay was stiff, or mixed with coarse sand or gravel, the point was unable to penetrate. These samples were sent to the Division of Soils, United States Department of Agriculture, for analysis.

DEPENDENCE OF FISHES UPON PLANT LIFE.

It is needless to go into the statistics of the value of the fish industry. The fresh-water fisheries alone amount to more than $4,000,000 annually, not to mention the capital invested in trout, bass, and other game fish. The importance of the subject from an economic point of view fully warrants an exhaustive study of the

A. Soil sampler, after Delbecque.

B. The grapple.

conditions of fish life and a thorough understanding of their food supply. As has been pointed out by both Reighard[1] and Ward,[2] a complete knowledge of the life of a fish can only be obtained by a study of the entire chain of biological relations existing in lakes and streams. In this chain plant life constitutes an important link. Plants stand between animal life and the inorganic substances it is unable to use. All aquatic animal life is ultimately dependent upon plants, which transform carbon, nitrogen, and other inorganic substances into organic compounds fitted for animal use. Directly or indirectly, then, plant life is necessary to the support of the fishes

[1] Loc. cit. [2] Ward, H. B. A Biological Examination of Lake Michigan. Bull. Michigan Fish Commission No. 6, 1896.

in our lakes and streams. The vigorous growth and reproduction of plants furnishes a large food supply for the smaller animals, which in their turn can reproduce more abundantly and provide a greater amount of food for the fish.

Barring enemies and artificial hindrances to increase, such as overfishing, fish will multiply up to the limit of the food supply, but can never overstep that limit. If the food supply can be increased, an increase in the number of fish will naturally follow.

PROBLEMS OF AQUATIC PLANT LIFE.

To understand the factors controlling the primary source of food in the Great Lakes, we must study the plant life from every standpoint; we must learn the life history of each species, its physiology, distribution, and methods of reproduction. The important problems are, of course, physiological: The relations between the plant and the medium in which it lives; what it takes from the water and what it returns to it; the character of the bottom most favorable to certain species; the methods of passing the winter and of reproduction; the relations between the larger plants and the microscopic plant and animal forms that live on and among them, and the physical conditions of the lake—all these must be studied and, in great part, understood before we can determine what plants should be placed in a given lake and how we can best introduce them.

These are some of the problems that most plainly present themselves and to which a study of the species found, together with their distribution, may be regarded as preliminary. This "taking an inventory," as Zacharias aptly expresses it, is useful, but not final. We desire to know with what forms we have to deal, but the addition of a few more names to our list must not be thought of equal importance with a study of the life histories of these species.

MACROSCOPIC AND MICROSCOPIC PLANT LIFE.

The plant life of the Great Lakes may be roughly grouped into macroscopic and microscopic. It is exclusively the latter that enters into the plankton. These unicellular plants are the primary source of the food supply, their great reproductive power supplying a constant source of food for the plankton animals, which, in turn, feed the larger forms.

Although the higher plants are not known to enter to any large extent into the diet of mature food-fishes, yet their importance in the economy of aquatic life must be great because of the myriads of minute animal and plant forms that find shelter and subsistence among them. These forms—the insect larvæ, mollusca, crustacea, rotifera, and others—are important as fish foods, and their absence must adversely affect the distribution of fish. The importance of shore and bottom vegetation was recognized by Ward (loc. cit.), who, in his report on the biology of the Traverse Bay region, makes constant reference to the scarcity of certain animal forms as due to the lack of plant life. The relative scarcity of hydra, worms, certain forms of rotifera, insect larvæ, and mollusca he attributes to the lack of bottom and shore vegetation, and says: "The barrenness of the littoral zone eliminates from the question of the food supply of this region one element which in Lake St. Clair was of extreme importance." This is recognized by Reighard (loc. cit.), who makes frequent reference to the abundance of certain animal forms in Lake St. Clair and connects it with the richness of the bottom flora.

TOPOGRAPHY.

The conditions in that portion of Lake Erie around Put-in Bay and Sandusky differ from those at St. Clair and at Traverse Bay. While the bottom and shore formations are not as abundant as in Lake St. Clair they are very much more abundant than at Charlevoix. The region about Put-in Bay and Sandusky is of limestone formation, Put-in Bay, or South Bass Island, East and West Harbor, belonging to the waterlime group, while about the mouth of the Portage River there is an outcrop of Salina shale. The channels between the islands have been scooped out of the limestone rock by glacial action, and the bottom is either of this rock or is covered with drift clay.[1] Much of the coast on the mainland is rocky and precipitous, but a great part of it is sandy beach (pl. 11, fig. 6), especially at East and West Harbors and at Port Clinton, while at Catawba Island and at Marblehead light the limestone rock juts out into the lake, breaking the continuity of the sand beach. The islands, of which there are on the American side six larger and as many smaller, usually present rocky shore lines to the waves (pl. 11, fig. 4), but there is one sand beach on South Bass Island and portions of the bay are less rocky than the west shore. The water is generally of considerable depth close to the rocks, and the bottom is covered with stone and gravel overlying a blue clay that comes to the surface in the deeper parts. In Put-in Bay the bottom is generally muddy close up to the shore, and in the western end, at Squaw Harbor, and also near the United States fish-hatchery, the bottom slopes gently, thus furnishing the conditions favorable to the growth of water plants. These parts of the harbor are, too, the most protected from the violence of the waves.

At four points on the mainland between Sandusky and Port Clinton there are extensive swamps, about upper Sandusky Bay, at East and at West Harbors, and along the Portage River at Port Clinton. These swamps are characterized by a great extent of low-lying muddy bottom, covered with varying depths of water and sloping back to low wet ground (pl. 11, fig. 1). They are intersected by many channels, some opening out to the lake or river, while others lose themselves in the body of the marsh. Pools of greater or less extent frequently occur. At Port Clinton and at Sandusky the swamps border the rivers and extend for miles up the stream, while at East and West Harbors they open directly into the lake by narrow channels, which are protected from wave action by sandbars.

DISTRIBUTION OF AQUATICS.

Phanerogamic water plants form a class distinguished from land plants by many differences of structure and form due to their peculiar habitat. The variety of form and the high development of land plants is wanting in aquatics, because a few types and relatively simple structure suffice to meet the nearly uniform conditions of their existence. Their distribution is almost world-wide, many of the species being found throughout the temperate zone and some even from the Arctic Ocean to the Equator. They grow in streams, pools, and lakes, in flowing and in still water; some species even flourish in stagnant water; and, together with marsh plants, they form the bulk of the vegetable matter in lakes and streams.

[1] Ohio Geological Survey, vol. II.

PLANT GROUPS.

The plants of this region may be roughly divided into swamp plants and water plants, the latter being such as are wholly submersed or have only their reproductive and small portions of their vegetative parts above water, or which float wholly or in part on the surface. The regions occupied by these forms can not be sharply delimited, because true water plants grow between the swamp plants throughout the greater part of the marsh. To these two groups must be added a few shore plants that affect, though perhaps to an insignificant degree, the vegetable matter in the lake. The shore line in this region is either sand or limestone, and the characteristic plants are such as are commonly found in similar locations. *Euphorbia polygonifolia*, *Triodia purpurea*, *Elymus canadensis*, *Cenchrus tribuloides*, *Salix longifolia* and *S. cordata*, *Cakile esculenta*, and *Polanisia graveolens* grow on the sandy beach (pl. 11, fig. 2). This vegetation has, however, no influence on the biology of the lake other than an occasional accidental one, such as the washing into the lake, by a storm, of parts of these plants. The same is true of the rock plants, although being almost constantly subject to wave action they are more frequently washed into the lake. Along a great deal of the shore of South Bass Island, as well as on the other islands of the group, the broken limestone rock is washed by the waves, and in the crevices of this rock a multitude of plants find a footing. The principal species in bloom during July and August were *Campanula rotundifolia*, *Steironema ciliata*, *Aster ericoides* and *A. polyphyllus*, *Carex eburnea*, and *Lobelia kalmii*. The rocks were nearly covered with lichens and a reddish alga. The unicellular algæ, which flourish in the many small pools among the rocks, are constantly washed out by the waves (pl. 12, fig. 1).

DESCRIPTION OF PRINCIPAL PLANT REGIONS.

Plants in Put-in Bay.—The plants in this bay were studied more thoroughly than elsewhere, owing to accessibility. Careful dredgings were made throughout the western part of the bay, including Squaw Harbor and the vicinity of the hatchery. Squaw Harbor is a shallow body of water averaging about 4 feet in depth and not exceeding 7 feet in the deepest part, with a rocky border which prevents a swamp formation of any extent (pl. 11, fig. 5). The mud bottom slopes gradually and is covered with a dense mass of vegetation. From the entrance of Squaw Harbor to the end of Gibraltar Island the water becomes gradually deeper, but does not exceed a depth of 15 feet, and reaches that depth only near the end of Gibraltar Island. The bottom changes as gradually from mud to clay, with some sand and gravel along the shore.

A bar separates Squaw Harbor from Hatchery Bay,[1] which is also shallow, nowhere over 11 feet deep and averaging perhaps 5 feet. The bottom of this bay varies much, being stony in some places and muddy in others. The water is turbid, and it is usually impossible to see plants more than 2 or 3 feet below the surface.

Plants in Squaw Harbor.—Squaw Harbor is bordered by a narrow strip of rush-like plants. These plants are limited abruptly on the land side by the rocks and on the other side by a depth of from 2 to 2.5 feet of water. Toward the east *Sagittaria rigida* forms a prominent group, extending about 30 feet from the shore and finding its limit of depth in about 2.5 feet of water. Looking over the plants

[1] For convenience I have applied this name to that part of Put-in Bay lying between Gibraltar Bar and the United States fish-hatchery. It opens by a ship channel directly into the lake.

from the water side, a gradual but striking change in the character of the leaves is evident. In the deeper water the petioles are rigid, sharply triangular, and tipped with a narrow blade sometimes scarcely distinguishable from the petiole. Nearer the land the blades are broader and the petioles shorter, and in the mud along the shore plants grow with broadly lance-shaped blades on petioles 8 to 10 inches long (pl. 15, fig. 1). Not infrequently blades are found with one or both sides lobed. This species also occurs on the other shore with *Scirpus lacustris*, but is not as abundant as on the east side. Wherever *Sagittaria rigida* and *Scirpus lacustris* occur together the former always occupies the deeper water. Near the shore *Typha latifolia*, *Carex pseudo-cyperus* var. *comosa*, and species of *Scirpus* form a background for the *Sagittaria*.

Scirpus lacustris is scattered along the east shore, but is not as abundant as on the other side, a few hundred feet away, where *Scirpus pungens* is the prevailing species. There are relatively few macroscopic forms in the water among the plants of *Sagittaria* and *Scirpus*, although various species of algæ are attached to the *Sagittaria* petioles. *Ceratophyllum* occurs, but not as abundantly as in the water between the two shore regions. Along the south shore there is a thick growth of *Dianthera americana*, and the shallow water of the harbor is filled with submersed forms, of which *Vallisneria spiralis*, *Myriophyllum spicatum*, *Naias flexilis*, *Ceratophyllum demersum*, and the various species of *Potamogeton* are the principal ones. These all grow together freely, the *Naias* in company with *Chara*, mostly *Chara fragilis*, covering the bottom as clover covers a field, while the other species nearly all rise to the surface. In the early part of the season few or no plants can be seen, but after the middle of August the surface of the water is covered with their floating branches. A patch of *Nuphar advena* and one of *Nelumbium luteum*, the latter but recently established, occupy part of the head of the harbor. *Characeæ* are scarce in this harbor, excepting some *Chara fragilis* in the deeper parts and a few smaller species on the edges of a little clay bank near the south end. Here were found, in water from 2 to 10 inches deep, a number of species, some in vigorous condition, others barely holding their own. Here I also found *Zannichellia palustris*.

The growth of *Sagittaria rigida* along the east side of Squaw Harbor is doubtless due to the protection from wave action afforded by Gibraltar Island and Bar in the mouth of the main harbor. The west side is more exposed to waves than the east side, and while *Sagittaria* is not a plant that endures heavy wave action, *Scirpus pungens* grows equally well on a muddy flat or on a surf-beaten bar. In this place it runs out along the point toward Gibraltar Island as far as it can find footing among the rocks where the water is not too deep. The thick growth of filamentous algæ on the petioles of *Sagittaria rigida* and over the stones along the east shore must also be attributed, at least partly, to protection from wave action. *Œdogonium* and *Spirogyra* grow luxuriantly attached to *Sagittaria* petioles just beneath the surface of the water, and these masses swarm with minute forms of animal and plant life. *Pithophora* sp. covers the stems and petioles in shallow water as well as the mud and damp stones along the shore. The coarse filaments of this alga form a network whose meshes are filled with crustacea, insect larvæ, and unicellular algæ.

Plants near Gibraltar Island.—The same species that flourish in Squaw Harbor extend out into the main bay to a depth of 10 feet or a little more. Everywhere from Gibraltar Island to the shore of South Bass Island the bottom of the bay is covered, generally thickly, with plants of which *Naias flexilis* and var. *robusta*,

Vallisneria spiralis and *Heteranthera graminea* are most abundant, but *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Potamogeton zosteræfolius*, *P. perfoliatus*, *P. perfoliatus richardsonii*, *P. pectinatus*, and *Elodea canadensis* are also plentiful. In some spots an abundance of *Chara contraria* was found with a trace of *C. coronata* and *Tolypella intertexta*, but there are few *Characeæ* in Put-in Bay. In the deeper parts of Lake St. Clair *Tolypella intertexta* covers the bottom with a luxuriant growth, but in Put-in Bay this species is scarce and the plants are small.

The sandbar running from Gibraltar Island to South Bass Island separates to some extent this part of the bay from the part about the fish-hatchery. The bar is usually covered with water from 1 to 4 feet in depth, but at times a great part of it is above water. On the east side of the bar the slope is steep, while on the other side the bar slopes gradually into Hatchery Bay. In the deeper water just east of the bar the vegetation is most luxuriant, great quantities of *Naias* and of *Vallisneria*, with other species, being brought up at every cast of the grapple. The bar is covered with a layer of cobblestones and pebbles, overlying the blue clay which covers the bottom throughout this part of Lake Erie. Of all the plants found on the east side of the bar, but one grows on it; this is *Vallisneria*, which in many places forms dense patches. Besides the *Vallisneria* the principal plant on the bar is *Potamogeton heterophyllus*, and this I did not find elsewhere in the bay except in one wave-washed place on the south shore. This species flourishes all along the bar, but especially toward the Gibraltar end, where it is accompanied by a few plants of *Potamogeton filiformis* and a dwarf form of *Naias flexilis* with close, compact habit and strong root system (pl. 18, fig. 2). These plants root in the clay between the stones and flourish wherever the stones and pebbles are not too thick.

Plants in Hatchery Bay and in the open lake.—In Hatchery Bay the narrow-leaved *Potamogetons*, such as *P. pusillus*, *P. zosteræfolius*, and *P. pectinatus*, with *Heteranthera graminea* and *Naias flexilis*, are especially abundant, and in quiet places on muddy bottom *Ceratophyllum demersum*, *Myriophyllum spicatum*, and *Elodea canadensis* are common. A few species of *Characeæ* also occur in this part of the bay, but nowhere in great abundance. Beyond a depth of 10.5 feet no plants were found, except one small plant of *Vallisneria* in the channel at a depth of 13.5 feet. A depth of 10.5 feet corresponds roughly with a line drawn from the northern extremity of South Bass Island to Gibraltar Island. Beyond this is the lake, and although the bottom is free from stones and of a soft clay, not a plant was found growing in it. This was the case wherever the lake itself was examined. Dredging trips were made to various points and the bottom carefully dragged, but without finding as much as a *Chara*, except that on one occasion a small amount of *Lyngbya wollei* was brought up. This alga grows much more abundantly later in the season, often choking up the fishermen's nets with its coarse filaments. Close along the shore the stones are covered with *Cladophora glomerata*, to which many diatoms are attached, and among which many minute forms find a home.

East Harbor.—At East Harbor there is a wide stretch of swamp intersected by channels which open into the lake by one deep and narrow channel protected from severe wave action by a sandbar. The bed of the channel is entirely free from plants, but along each side is a border of *Vallisneria* and *Potamogeton*, the side toward the water being sharply defined by the current. On the west side there is a small bank of *Vallisneria* with some *Potamogetons* in the shallower water, while beyond these are

Scirpus pungens and *S. lacustris*, growing in wide stretches over the low sandbar and in the shallow lagoon behind the bar. The old rootstocks of these species of *Scirpus* can be seen everywhere in 6 to 9 inches of water, forming a network over the sand. In the lagoon, with *Scirpus pungens*, grows *Naias flexilis robusta*, long and slender, while in the shallow water on the exposed bar the dwarf form of *N. flexilis*, previously found in similar places in Put-in Bay, is not uncommon.

On the east side of the channel the number and kinds of plants is greater, in spite of the fact that the prevailing winds drive the waves against the shore. The probable reason is that these waves have washed a great deal of mud to that side, making more favorable soil for the growth of the plants. *Vallisneria* occupies the deeper parts on the east side of the channel as well as on the west, growing in 6 to 7 feet of water, but is present also among the other species in shallower places. Toward the land from the *Vallisneria* are the *Potamogetons*, *P. zosteræfolius*, *P. pectinatus*, *P. lonchites*, and *P. perfoliatus richardsonii*, with *Heteranthera graminea* occupying the ground in 3 to 5 feet of water and occasionally in the shallower places. In 1 to 2.5 feet of water, among the *Scirpus lacustris* and *S. pungens*, *Myriophyllum*, *Naias*, and *Elodea* are the principal species, but, as already remarked, the forms common in deeper water also frequently occupy this ground. In some places along this shore the *Scirpus* is mixed with *Zizania aquatica*, and on the sandy bank *Scirpus pungens* shares the ground with *Equisetum robustum*.

The sandbar which protects the channel entrance is large and is covered with water varying in depth from 6 inches to 2 or 3 feet. *Scirpus pungens* grows in many places on the most exposed situations in water up to a foot deep. Beyond the *Scirpus*, in places exposed to the heaviest surf during storms and where the water is 6 to 12 inches deep, I found scattered tufts of *Potamogeton heterophyllus*. The form is the same as that growing abundantly on the bar at Gibraltar Island, where it was found in fruit, but no fruiting specimens were found at East Harbor. In neither case did it have floating leaves, the plants growing in tufts with many branches coming out from near the base of the stem. This is the form which Dr. Morong named var. *longipedunculatus*.

Character of the vegetation up the channel.—A short distance from the entrance the channel divides, one branch going east, the other west; the latter again divides, one branch turning southwest, the other continuing in a westerly direction. With slight exceptions a description of the vegetation along the eastern branch will apply to this entire swamp region.

Just where the channel turns toward the east is a sandy beach covered with 2 feet or less of water, and here grow two forms of *Naias*, *N. flexilis robusta* and the dwarf form of *N. flexilis*, besides several species of *Characeæ*, which are more abundant here than elsewhere in the swamp. In an area not over 200 feet long by 10 wide I found four species of *Nitella* and four of *Chara*, all of low, compact habit, though in other locations plants of some of the same species grow long and of open habit. *Nitella subglomerata* and *Nitella polyglochin* grow in clusters a few inches across and as many high, while *N. tenuissima* and *N. batrachosperma* grow in about 1 foot of water with their branches spread out flat on the sand. *Chara fragilis* grows with close, compact habit; *Chara contraria* and its variety *subinermis* are here low, delicate plants, growing in the shallower places; *Chara coronata* has a habit different from that of the same species in the deep, quiet pools, being stocky, with short

internodes and very compact. *Chara sejuncta* is the largest species here, and is notable for its long runners.

Here *Vaucheria tuberosa*, a plant usually found in deeper water, grows on the sand in thick, compact tufts, and looks almost black at the bottom of 2 feet of water. No Phanerogams, save a few plants of *Naias*, grow in this bed of *Characeæ*, but nearer the channel, in deeper water, is a bank of *Vallisneria* and *Potamogeton*. The current is slower here, and in many places the channel is entirely filled with vegetation consisting mostly of *Vallisneria*, *Heteranthera graminea*, *Potamogeton pectinatus*, *P. lonchites*, *P. lucens*, close along shore where the water is quiet, and *P. perfoliatus* with some *Nuphar* and *Nelumbium* in about 3 feet of water. Nearer shore the entire channel is lined with *Sagittaria rigida*, which nearly everywhere occupies the deepest water within the zone of submersed forms. In quiet places there are beds of *Elodea* with *Myriophyllum*, *Ceratophyllum*, and *Utricularia vulgaris*, while *Naias flexilis* and *Nitella polyglochin*, which here grow long and slender, with open spreading habit, are scattered everywhere between the stems of the larger plants in 1 to 2 feet of water. From the *Sagittaria rigida* zone, toward the land side, we come in succession to *Scirpus fluviatilis*, with a little *S. pungens* and *S. lacustris*, *Sparganium eurycarpum*, *Typha latifolia*, and *Sagittaria latifolia*. *Dianthera americana* begins in about 18 inches of water and continues to the muddy shore, mixing, in 6 to 10 inches, with *Scirpus atrovirens*, *Acorus calamus*, *Polygonum muhlenbergii*, and *Asclepias incarnata*, while on the muddy shore it accompanies *Phalaris arundinacea*, *Calamagrostis canadensis*, and *Convolvulus sepium*. Everywhere on the water, between the larger plants, are *Lemna minor* and *Lemna polyrhiza*.

A species of *Sagittaria* not in fruit, but probably *S. latifolia*, is mixed with the more landward specimens of *Sagittaria rigida* and continues toward the shore, its leaves becoming constantly broader as it approaches shallower water. On the wet bank groups of *Hibiscus moscheutos* make the swamp gay with their flowers.

The swamp on the south side of the channel.—On the south side of the channel the swamp covers many acres and is overgrown with rush-like plants. The species are always somewhat mixed, but in each association some one tall species is clearly predominant. Sometimes the boundaries are sharply limited and this in spite of the fact that no differences in soil or in depth of water can be detected. *Sagittaria rigida*, which is nearest the open channel, gradually gives place to *S. latifolia*, which is mixed with a little *Zizania aquatica* and *Sparganium*. Following this is a broad zone of *Scirpus lacustris* of nearly pure growth, then *Scirpus fluviatilis* mixed with a little *S. lacustris*, which soon increases to a second broad belt mixed this time with some *Sparganium*.

Throughout all these associations both *Sagittaria rigida* and *S. latifolia* occur, the latter being common. The water is about the same depth throughout this region, varying from 1 to 1.5 feet, and the bottom is a soft mud. The second zone of *Scirpus lacustris* encircles and sharply limits a large bed of *Sparganium eurycarpum*. The water here is a little deeper, being nowhere less than 1.5 feet, and the bottom seems softer, no other differences being noted. The *Sparganium* is sparingly mixed with *Pontederia cordata*, *Sagittaria rigida*, *S. latifolia*, and a few plants of *Scirpus lacustris* and some *Nelumbium*. Beyond the border of *Scirpus lacustris*, which encircles this bed of *Sparganium*, is a bed of *Typha latifolia* in the same depth of water as the *Scirpus*. *Naias flexilis* grows among the taller plants, and other

low-growing aquatics are not uncommon. In shallower water *Dianthera* grows abundantly, and *Sium cicutæfolium* occurs in 6 inches of water with *Asclepias incarnata*. Beyond the *Typha* is a vast stretch of *Phragmites communis* occupying shallow water or exposed muddy places.

Such is the nature of the swamp and the arrangement of the species. A few may be called dominant species. These grow in groups from which the other dominant species are nearly or quite excluded, but the spaces between the larger plants are occupied by many small forms which occur throughout the swamp.

Plants growing about the head of the channel.—At the head of this branch of the channel is a quiet pool some 3 to 5 feet deep, where such forms as *Utricularia vulgaris*, *Myriophyllum*, *Ranunculus divaricatus*, *Bidens beckii*, and *Ceratophyllum* find a congenial home and fill the water. *Heteranthera graminea* and *Potamogetons* also find favorable conditions here; *P. natans*, *P. pectinatus*, *P. pusillus*, *P. zosteræfolius*, *P. robbinsii*, *P. lucens*, and *P. amplifolius* grow together in the clear, quiet water. *Nuphar advena* and *Nymphæa tuberosa* grow in places not occupied by *Utricularia* and *Ceratophyllum*, while the bottom is overgrown with *Elodea*, *Chara coronata*, and *C. gymnophila* var. *michauxii*. The average depth of water is 3 feet, with a soft mud bottom. On all sides this pond is surrounded by *Zizania aquatica*, which grows on a similar bottom and in the same depth of water as the *Scirpus* and *Typha* found down the channel.

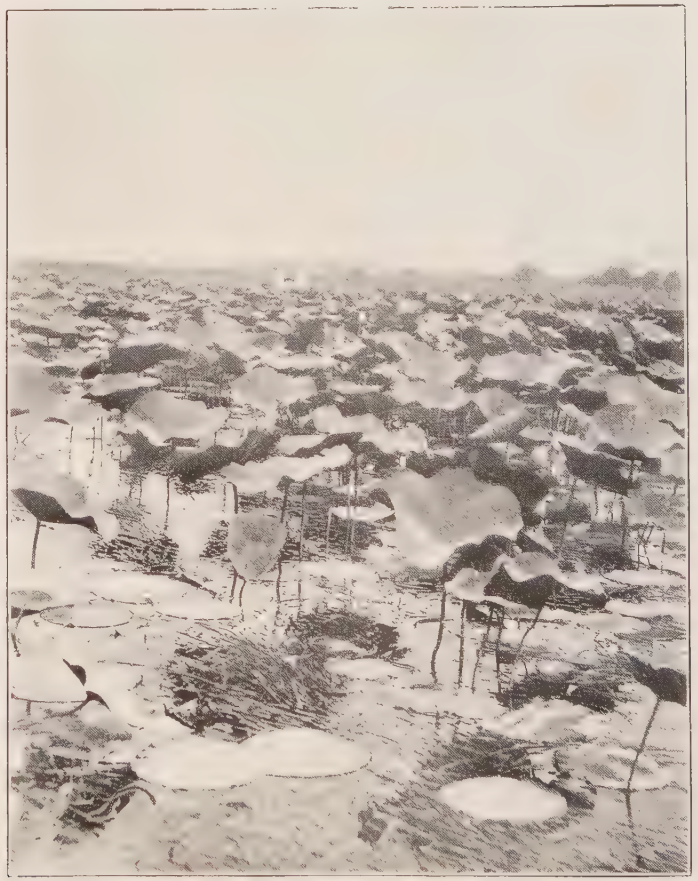
Growth of Nelumbium luteum.—The conditions along other channels are very similar to those just described, except that along the west channel *Nelumbium luteum* flourishes. The immense yellow flowers rising just above the great dark-green standing leaves and the water covered with huge floating pads make this the most striking formation of the swamp (pl. 12, fig. 2). The *Nelumbium* grows in from 2 to 4 feet of water, or stray plants may be found in less than 2 feet. Many of the floating leaves were 20 to 24 inches across and the standing ones not much smaller. At Upper Sandusky Bay I found a floating leaf 26 inches in diameter and another with a petiole more than 5 feet in length. Both at Sandusky Bay and along the Portage River the acreage of *Nelumbium* was greater than at East Harbor, but nowhere did the plants present a more vigorous growth or so magnificent an appearance.

Portage River swamps.—The Portage River swamps differ somewhat from those just described, but not sufficiently to require a detailed description. A much greater area is covered, and the swamp extends for miles up the river; but in general the distribution of plants is the same—*Heteranthera*, *Vallisneria*, and *Potamogetons* along the stream, followed by *Sagittaria rigida* and the other marsh plants. The vast swamp is dotted here and there with pools in which *Utricularia* and similar plants flourish. Here also I found *Naias gracillima* and *Typha angustifolia*, the latter growing in a brownish clay differing from that common along this stream. In many places the bed of the river was entirely devoid of plants, although there was no perceptible current. On the muddy shore in a quiet place the bottom was covered with a thick growth of *Chara sejuncta*, accompanied by *Nitella subglomerata*, and in some pools *Nitella tenuissima* and *N. polyglochin* grew in 3 feet of water.

Swamps about Sandusky Bay.—At the head of Sandusky Bay the swamps are also very extensive, the general features being about the same as of those along the Portage River. Much of the water is from 3 to 6 feet deep and supports only

Bull U S F C 1901. (To face page 66)

1. WAVES WASHING THE SHORE.



2. NELUMBIUM LUTEUM, A FEW ACRES GROWING AT EAST HARBOR, OHIO.

The standing leaves are about 2½ feet above water.

a moderate growth of *Vallisneria* and *Potamogeton*, mostly *P. perfoliatus* and *P. pectinatus*. The water is very muddy, and this may account for the scarcity of vegetation; for near the shore, where the water is clear, plants are more abundant, such bottom forms as *Chara*, *Nitella*, and *Naias*, as well as *Potamogetons*, being present.[1] In the clear water also were floating great masses of a species of *Mesocarpus* swarming with crustacea and other minute forms of animal life, while in some quiet places *Hydrodictyon* was found. Lower Sandusky Bay averages 10 to 12 feet deep, and no plants were found except scattered clumps of *Potamogeton pectinatus* and *P. perfoliatus*. The parts of the bay above and east of the city were but hastily examined. For the most part there is a scanty growth of *Potamogeton lonchites*, *P. perfoliatus*, *P. pectinatus*, *P. prælongus*, and *P. zizii*. In some places the water is clear, and one sees on the bottom, at a depth of 5 to 8 feet, *Potamogeton amplifolius* and *P. lucens* and the straight, slender shoots of *P. robbinsii*, as well as most of the other species native to these waters. Here *Eleocharis palustris vigens* grows just beyond *Scirpus pungens*, its stem below the water line covered with colonies of *Rivularia*.

ESTABLISHING ZONES.

It is clear that such a grouping of plants into zones as was established by Magnin[2] for the lakes of the Jura and by myself for Lake St. Clair is impossible for any region examined in 1898. Only two groups are possible—one including all submersed forms and those with floating leaves, the other all the remaining species with emersed leaves and growing with roots and parts of the stem in water. All the species of the three submersed and floating zones are either mixed together in a narrow border along the channels or cover the entire bottom of shallow harbors. Among the swamp plants it is sometimes possible to draw a more or less definite line between the landward forms and those growing in deeper water, but even this is so often vague and unsatisfactory that I do not consider it of any real value. The species intermingle so much on common ground that an attempt to separate them would only result in confusion.

INFLUENCE OF VARIATION OF DEPTH OF WATER ON PLANTS.

The influence of changes in the depth of water on the distribution of aquatics is important, but unfortunately we have little data on this subject. Through the kindness of Col. James Smith, of the engineer's office in Cleveland, Ohio, I secured a table showing the depths of water at Cleveland from 1859 to June, 1898. From the table it appears that since the records began the greatest difference in water level has been 2.86 feet between high water in 1859 and low water in 1895. In 1859 the water was nearly 1.5 feet higher than it was during the summer of 1898. This must have made a great increase in the extent of the swamp, especially of those portions in which the submersed forms could flourish. In 1895, however, the water suddenly fell from 0.4 foot below mean in 1894 to 1.39 feet below in 1895, causing a decrease in the submerged area and the destruction of a great deal of submersed vegetation. In the following year the water rose 0.64 foot and has continued to rise slowly

[1] This may also be connected with the character of the bottom. In the first locality the bottom contains a much larger percentage of clay than in the second.

[2] Magnin, M. Ant. Recherches sur la Végétation des Lacs du Jura. Revue Gén. de Bot., t. v (1893), p. 303.

since that time. Absence of data concerning the aquatic plants growing during those years makes it impossible to say what effect this change of level has had, but it is certain that data collected in any one year can not be depended upon to give the normal depth at which certain plants flourish. Most species of aquatics being perennial, they may start during periods of low water in places that will be too deep for them during high water, but where they can struggle along for a season or two before perishing.

ECOLOGICAL GROUPS.

Many attempts have been made in recent years to arrange all plants into groups according to the conditions under which they flourish and the manner in which they adapt themselves to their environment. Warming, Drude, and others have adopted certain groupings, but as yet, save on the main divisions, there is no agreement among plant geographers. All classifications, however, include the hydrophites, or water plants, as one of the main divisions, and split this up into a number of smaller groups, each group including all those plants having more or less similar life habits, although perhaps belonging to widely separated families. Ecological groups, indeed, are not in the least based on taxonomic characters. Among the free-swimming, submersed forms are such widely different species as *Utricularia vulgaris*, *Lemna trisulca*, and species of *Mesocarpus*, *Spirogyra*, and *Lyngbya*, besides many others, both macroscopic and microscopic. The attached, low-growing, submersed forms include the *Naiadaceæ* and *Characeæ*, while species of *Potamogeton* and *Nymphæa* belong to the group with floating leaves. It would be possible to make a large number of groups, attempting to express in this manner all the ways in which water plants are influenced by currents, depth, light, and the other factors bearing upon an aquatic habitat, and in so far as such groups represent biological facts they have a value. It is doubtful, however, whether any but the broader divisions are sufficiently stable to be of use, the great adaptability, within certain limits, of the aquatic organism rendering the boundaries of the smaller groups too indistinct to be readily recognized. This is illustrated in *Vallisneria spiralis*, the long ribbon-like leaves of which are thought by some to be especially well fitted for floating downstream in a rapid current, but it grows equally well in almost stagnant water. *Potamogeton heterophyllus*, when growing in quiet pools, produces floating leaves, but when on a surf-beaten bar it branches freely from the base and the floating leaves are absent. I shall therefore divide the water plants of our region into only five groups, as follows:

1. Free-swimming, microscopic forms in the open lake: The Plankton.
2. All other unattached species, macroscopic and microscopic: *Utricularia vulgaris*, *Lemnæ*, *Ceratophyllum demersum*, and many algæ growing in quiet places.
3. Attached submersed plants: *Naias*, *Chara*, *Cladophora*, *Vallisneria*, *Potamogetons*.
4. Attached plants with floating leaves: *Nymphæaceæ*, *Potamogetons*.
5. Swamp plants.

The Plankton includes, of course, both animal and vegetable forms, among the latter being species of *Merismopedia*, *Pediastrum*, *Sphærozyga*, *Clathrocystis*, and many diatoms. Species of *Desmideæ* sometimes occur, but probably by accident. The species of the plant Plankton being mostly without voluntary motion, are subject to all the currents and movements of the water.

In the second group are many widely distant forms, all growing in quiet pools and sheltered places. Among the higher plants *Utricularia vulgaris*, *Ceratophyllum*

demersum, *Lemna trisulca*, *L. minor*, *L. polyrhiza*, and *Wolffia columbiana* are free-swimming forms, either submersed or floating. With them are associated masses of *Mesocarpus*, *Spirogyra*, *Hydrodictyon*, and frequently quantities of *Oscillaria*, *Lyngbya*, and other related forms.

Microscopic algæ, especially *Desmideæ* and *Diatomaceæ*, occur in great numbers upon the larger plants in quiet water. They are especially numerous in the silt and dirt that collect upon narrow-leaved plants, as *Utricularia vulgaris* and *Bidens beckii*, but they are infrequent on *Ceratophyllum*, even when this grows near plants of *Utricularia* well supplied with microscopic life.

The plants of the third group occupy by far the largest place in aquatic vegetation. Though not always as conspicuous as the plants with floating leaves, they cover a much greater area and make up the mass of the vegetation. The *Characeæ* combine with *Naias* and *Elodea* to cover the bottom in water up to 10 or 12 feet in depth. *Heteranthera graminea*, *Vallisneria spiralis*, *Bidens beckii*, species of *Myriophyllum*, *Ranunculus*, and *Potamogeton* grow to near the surface of the water, and in favorable locations make a dense growth. *Bidens beckii* also has aerial leaves. In this group must be included the attached submersed algæ, as *Chætophora*, *Cladophora*, species of *Œdogonium* and the like.

FIG. C.—*Potamogeton lonchites*, section through a portion of submersed leaf.

The *Potamogetons* and *Nymphæaceæ* of the fourth group are nearly all vigorous plants and form the most conspicuous feature of aquatic vegetation. In our waters the plants of this group are *Nymphæa tuberosa*, *Nuphar advena*, *Nelumbium luteum*, *Polygonum muhlenbergii*, and several species of *Potamogeton*. *Nelumbium luteum* has both floating and emersed leaves. The root-stocks of the *Nymphaceæ* are thick and stout, while those of the Potamogetons are slender. The floating leaves are always thick and leathery.

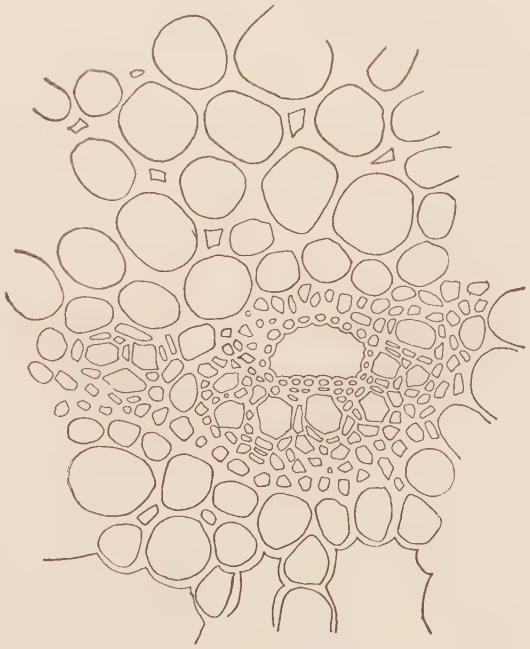


FIG. D.—*Potamogeton lonchites*, section through a bundle.

To the swamp-plant group belong all of the species rooting in the mud and not truly aquatic, including such forms as *Sagittaria*, *Typha*, *Sparganium*, *Alisma*, *Acorus*, *Dianthera*, many *Cyperaceæ*, and some grasses. These all root in the mud in shallow water and have nearly their entire vegetative system exposed to the air. They are generally characterized by slender stems and long, narrow leaves. In *Sagittaria*, *Sparganium*, and *Typha* the lower portion of the stem is usually thick and spongy;

the stems are in all cases well supplied with air spaces. Rootstocks are common and the plants generally spread locally by this means.

ADAPTATION OF WATER PLANTS TO THEIR ENVIRONMENT.

It is not the purpose of the writer to enter into the details of the structure of water plants, but a few general remarks indicating the relation between the structure of leaf and stem and the medium in which these plants grow will not be out of place.

Aquatic plants show in form and structure special adaptations to their environment. Their development is affected by dim light, the motion of the water, absence of transpiration, difficulty in obtaining oxygen, and the necessity of taking the mineral substances needed through the entire plant system instead of by means of roots.

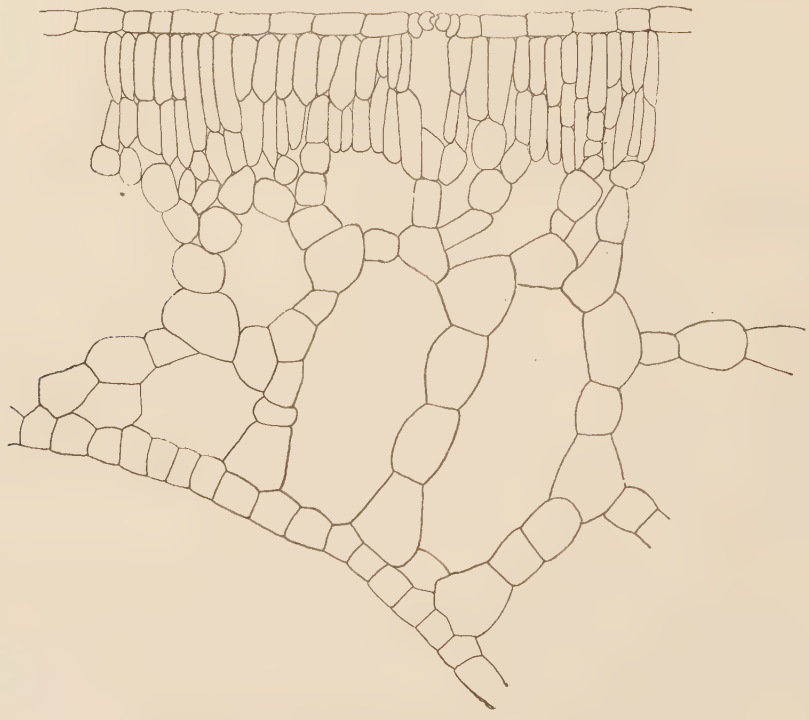


FIG. E.—*Potamogeton lonchites*, section through floating leaf.

Even in clear water there is some loss of light by filtration and by reflexion, and in the muddy water common in the Put-in Bay region this loss must be considerable. Other things being equal, plants would be limited in their growth by the depth of the water. That the plants within our region do not occupy all the places where depth of water would allow will be shown later on to be perhaps due to the character of the bottom. To make the most of the dim light that reaches them at the bottom of several feet of water, such plants as *Naias* and the *Characeæ* have numerous narrow leaves, always ascending and of the same structure on both sides (fig. H). The stem also is green and assists in the work of assimilation. A narrow or finely divided leaf is common among water plants. In *Utricularia*, *Ceratophyllum*, *Bidens beckii*, and *Ranunculus* the leaf is split into many narrow divisions; in *Elodea*, *Naias*, and in

the fine-leafed *Potamogetons* the leaves are linear or narrowly lanceolate, sometimes almost capillary, while *Vallisneria* has long ribbon-like leaves that frequently attain a length of 6 feet. The broad submersed leaves of such species as *Potamogeton perfoliatus*, *P. amplifolius*, *P. lonchites*, and *P. lucens* are very thin and consist in great part of but three cell layers, an upper and lower epidermis and a median layer, all of the cells having essentially the same character.

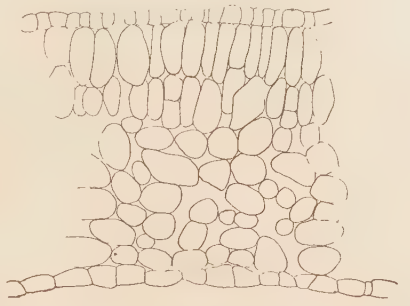


FIG. F.—*Bidens beckii*, section through portion of aerial leaf.

This broad, thin leaf is an ideal one for making the most of the dim light, but it is not so well adapted to withstanding the motion of the water. To offset this, these broad leaves have ribs that are wanting in other submersed leaves, and in these ribs bast fibers are found which, according to Schenck,[1] are absent in all other submersed leaves. In *Naias flexilis* the leaf is but two cell layers in thickness except at the midrib, and in *Elodea* an upper and a lower epidermis alone make up the thickness of the leaf.

A palisade parenchyma, so universal in the leaves of land plants, is entirely wanting in submersed leaves, the chlorophyll being arranged in the epidermal cells and on the tangential as well as the radial walls (see figs. F and G, portions of aerial and submersed leaves of *Bidens beckii*). The absence of stomata from most submersed leaves and the thinness of the epidermal cell walls are to be expected in a medium where adaptations for controlling transpiration are unnecessary.

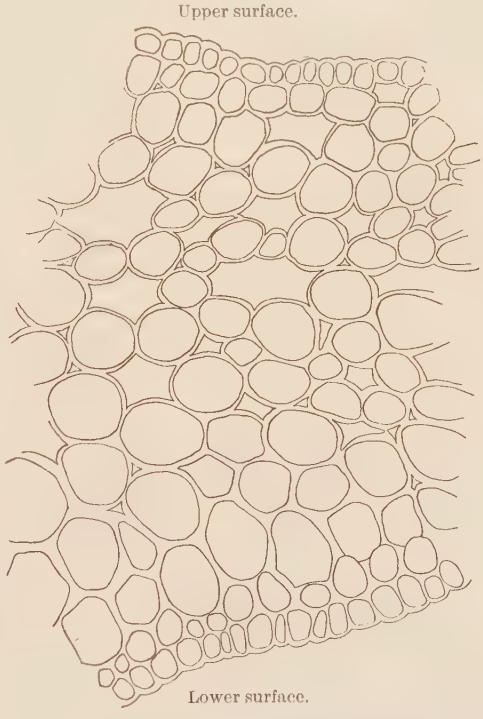


FIG. G.—*Bidens beckii*, submersed leaf.

The stem of the submersed aquatic with its central cylinder and reduced mechanical elements is well adapted to the movements of the medium, while the numerous and often large cavities supply an abundance of air to all parts of the plant. The reduction of the vascular bundles is one of the most striking features. In some aquatics, as *Naias*, no vascular bundles remain, their place being taken by a central canal (fig. K). This canal is also present in the *Potamogetons* and in some dicotyledons, as *Ceratophyllum* (pl. 13, fig. 5), and represents the wood portion of the bundle, an occasional ring or spiral indicating the former

[1] Schenck, H. Vergleichende Anatomie der Submersen Gewachse. Bibliotheca botanica, Heft 1, 67 pp., 1886.

presence of vessels. In *Bidens beckii* the dicotyledonous type of bundle is found, but the bundles are small and far apart. Between the bundles and the epidermis there are numerous cavities separated from each other by layers of tissue one cell in thickness (pl. 13, fig. 1). In *Ceratophyllum* the dicotyledonous type of stem has been obliterated and the entire stem is composed of parenchymatous cells, those of the

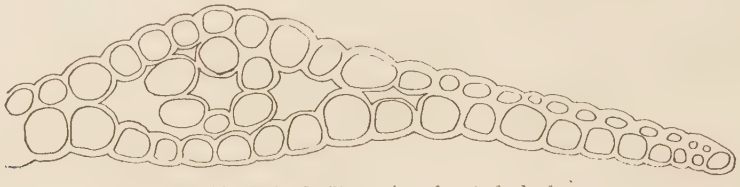


FIG. H.—*Naias flexilis*, section of part of a leaf.

central cylinder being only slightly differentiated. The stem is strengthened by collenchymatous thickening of the angles of the cell walls (pl. 13, fig. 6).

The *Potamogetons* having the monocotyledonous type of bundle differ from *Bidens beckii* in the central cylinder, but outside of this central cylinder the two forms have a similar structure. A sheath of thick-walled cells surrounds the central cylinder, and such cells are also frequently clustered about the inner side of each bundle. In some flat-stemmed *Potamogetons*, as *P. zosteraefolius*, groups of thick-walled cells are placed at irregular intervals just beneath the epidermis (pl. 13, fig. 4).

The structure of the floating leaf shows many striking differences from the submersed leaf, due to the difference in environment. The cells of the upper epidermis of the floating leaf are smaller than in the submersed leaf, with thicker outer walls, and frequently of more irregular outline. Stomata are confined to the upper epidermis. Below the epidermis are one or two layers of palisade tissue with the chlorophyll arranged on the radial walls. Between the palisade tissue and the lower epidermis there are large cavities separated by partitions one cell-layer thick (figs. C, E).

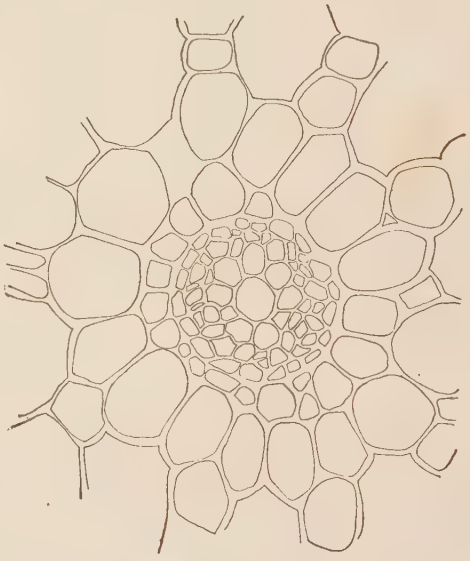
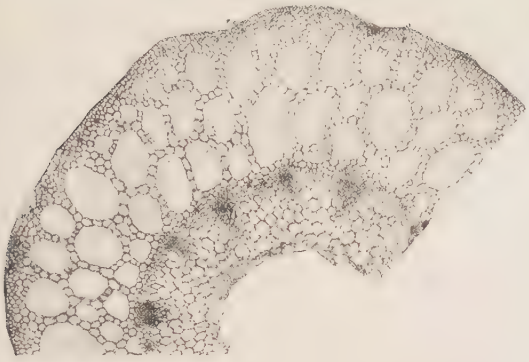


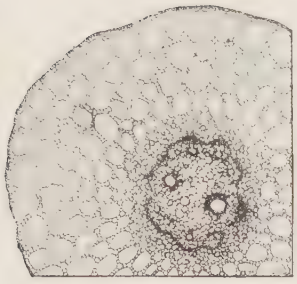
FIG. K.—*Naias flexilis*, cross section of central cylinder.

The lower epidermis is composed of larger, thinner-walled cells than the upper epidermis, and is devoid of stomata. Floating leaves are of firmer texture than submersed ones and have some protection against injury by water. This protection in most aquatics is a waxy covering (Schenck), but in *Nelumbium luteum* it consists of countless papillæ, each arising from an epidermal cell. A layer of air is always held by these projections, so that water falling on the leaf stands in great drops, as if on an oiled surface, until it can run off.

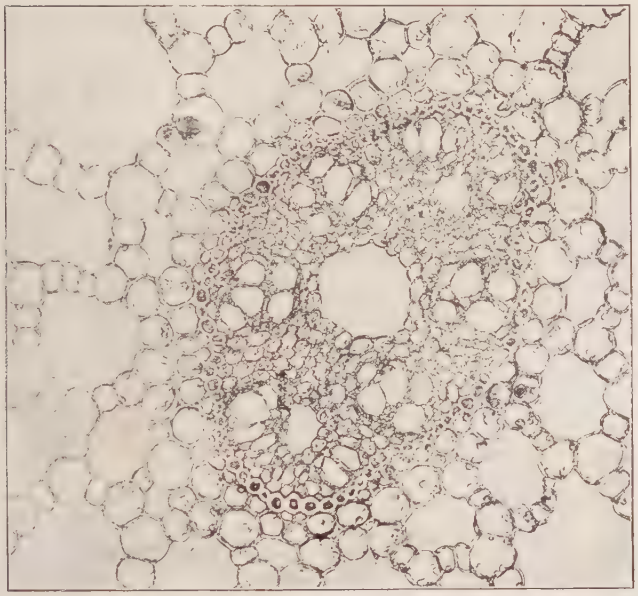
Nelumbium luteum has both floating and emersed leaves. There is no essential



1. BIDENS BECKII. CROSS SECTION OF A PORTION OF A STEM

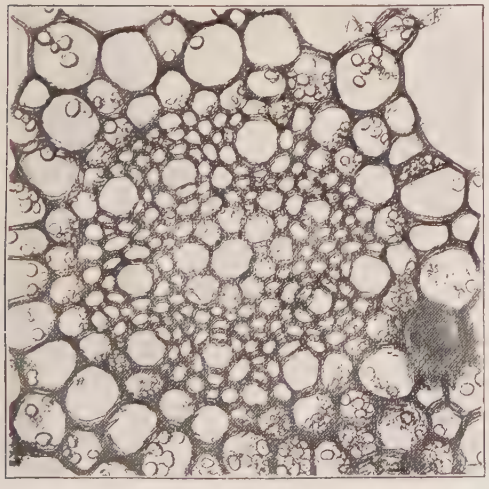


2. POTAMOGETON LONCHITES, CROSS SECTION OF A PORTION OF THE STEM.

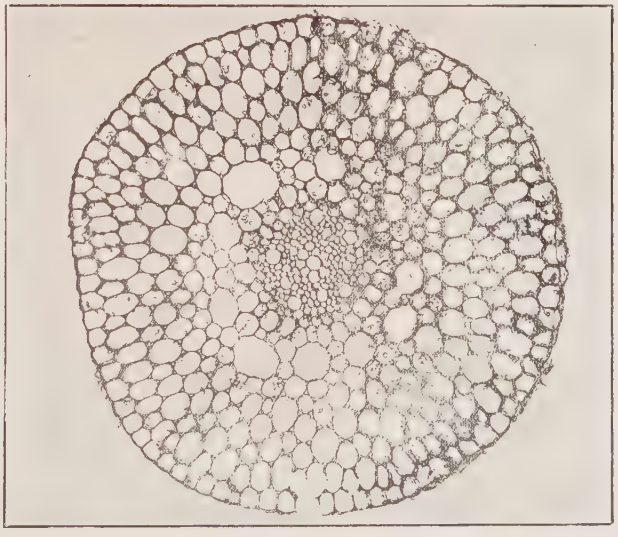


3. POTAMOGETON ZOSTERÆFOLIUS, CROSS SECTION OF CENTRAL CYLINDER

4. POTAMOGETON ZOSTERÆFOLIUS, CROSS SECTION OF A STEM.



5. CERATOPHYLLUM DEMERSUM, CROSS SECTION OF THE CENTRAL CYLINDER.



6. CERATOPHYLLUM DEMERSUM, CROSS SECTION OF A STEM.

difference in the structure of these two, except that the emersed leaf is much better provided with ribs, which, besides being more numerous, are stronger than those in the floating leaf.

ROOTS AND RHIZOMES.

Some aquatic phanerogams have so completely adapted themselves to a watery medium that they have dispensed with roots except in the germinating seedling, and in *Ceratophyllum* even these are almost wholly suppressed. With the exception of *Utricularia*, *Ceratophyllum*, and *Wolffia*, all phanerogams in our waters produce some roots. In *Lemnaceæ* these are slender organs serving to keep the plant in position on the surface. The rooting aquatics, as the *Potamogetons* and *Myriophyllum*, are provided with roots that, according to Schenck,[1] have no purpose save to anchor the plant. Hochreutiner[2] has endeavored to show that the roots of *Potamogeton* have another function. In experiments tried by him at Geneva, it appeared that eosine solution was absorbed by the roots and passed up the stem much more readily than it passed through the leaves. If this function of the roots of aquatics can be proven, it will help to explain some observations referred to under the discussion of the soil samples.[3]

ROOTSTOCKS.

Most aquatics and swamp plants have rhizomes or running rootstocks by which the species often spreads over considerable areas. On Gibraltar Bar the runners of *Potamogeton heterophyllus* ramify in all directions, and specimens of *Potamogeton lonchites* were collected at Sandusky showing extensive runners bearing buds at their ends. *Heteranthera graminea* has long black rootstocks. The thick rootstocks of the *Nymphæaceæ* buried in the mud give rise year after year to leaves and flowers and produce an abundance of strong fibrous roots. *Sparganium eurycarpum*, *Sagittaria latifolia*, *Typha latifolia*, *Juncus torreyi*, *Scirpus pungens*, and *S. lacustris*, among swamp plants, were specially examined for root systems. All are well supplied with running rootstocks, those of the species of *Typha* and *Scirpus* being particularly strong and widely spreading. Probably many square feet in an association of *Scirpus* and *Typha* are occupied by the plants of one system, each plant connected with all others of its species by the thick rhizomes. (See pl. 14, figs. 1–4; pl. 16, fig. 1; pl. 17, figs. 4, 5. *Typha*, *Nuphar*, *Potamogeton*, *Juncus*, *Scirpus*, *Sparganium*.)

REPRODUCTION, PROPAGATION, AND WINTERING.

In most aquatics the reproductive organs show the influence of the medium less than any other part of the plant. Such typical aquatics as *Utricularia* produce showy flowers and the seeds ripen above water. Most aquatics, however, ripen their

[1] Schenck, H. Die Biologie der Wassergewächse, Bonn, 1886.

[2] Hochreutiner, Georges. Études sur les phanerogames aquatiques du Rhône et du port Genève. (Revue gén. de Bot., t. VIII, p. 158.)

[3] Since writing the above, Mr. R. H. Pond, while a special assistant to the United States Fish Commission, has investigated the relation of water plants to the solid substratum. A summary of results has been published in Science, vol. XIII, No. 320, February 15, 1901, and is in part as follows:

"1. Plants rooted in soil exceed in vegetation and dry weight plants rooted in sand or merely suspended.

"2. Plants rooted in sand or merely suspended contain starch, calcium, and magnesium in excess, while they are lacking in nitrogen, potash, and phosphoric acid.

"3. Lithium nitrate is absorbed by the roots and conducted to the upper portions of the plant, where it may be detected with the spectroscope."

These results confirm the work of Hochreutiner and justify the views expressed on page 76 as to the importance of the soil for the growth of aquatics.

seeds below the surface, although the flowers are borne on emersed peduncles and have no adaptation for water fertilization. In the well-known case of *Vallisneria spiralis* the water assists in fertilization. The male flowers are borne on scapes at the base of the plant. When the inclosing spathe ruptures, the flowers rise to the surface and float about until they come in contact with the stigma of the female flower, to which some of the pollen adheres. After fertilization, the female flower is drawn below the surface, where the seeds ripen.

Our knowledge of the germination of the seeds of aquatic plants is still very fragmentary. The seedlings of rootless aquatics show the greatest departure from land forms. In *Ceratophyllum* a short radicle is developed, but it never grows out into a primary root, nor are other roots formed. In the *Potamogetons* and other rooting species the special adaptations for an aquatic existence in the seedling are not so marked. A primary root is developed, which later perishes and gives place to adventive roots.

Kolpin Ravn[1] has studied the power of seeds of aquatic and marsh plants to float and he finds that most seeds are heavier than water and thus can not float unless adhering in masses; or they may not be easily wet, when they will float in spite of their weight. Some float but a few days and their distribution is local. Many seeds, however, are doubtless carried by currents and water fowl, although the seeds of true aquatics are not well adapted to spread by animal agency, and it is probable that waves, floods, and water currents are more important in this respect than animals.

The active vegetative propagation and the perennial character of water plants have tended to reduce the importance of seed production. Many aquatics produce seed much less freely than land plants and in some seed production occurs but seldom or has never been recorded. *Ceratophyllum*, *Elodea*, and *Lemnaceæ* may grow for years in one locality and never produce seed. *Potamogeton robbinsii* is not known to seed. In the Put-in Bay region I was unable to find *Potamogeton amplifolius* in fruit, and fruits were scarce on *P. zosteræfolius*, *P. pusillus*, and *P. freisii*. The last three propagate by winter buds, and are perhaps losing the power to produce seed.

BUDS AND OFFSETS.

Besides rhizomes water plants propagate vegetatively by simple offsets and pass the winter by various means. Almost any fragment of a plant of *Elodea* when in water may continue to grow and produce a new plant. The same is true of *Ceratophyllum*, *Utricularia*, many *Potamogetons*, *Myriophyllums*, etc.

Some species pass the winter unchanged at the bottom of the water. Of these are *Zannichellia palustris*, *Ceratophyllum*, *Vallisneria*, and some species of *Potamogeton*. Among *Potamogetons*, *P. pectinatus* is remarkable for wintering by means of tubers produced at the ends of special roots. *Vallisneria* also produces a pseudo tuber, which is really a bud at the end of a rootstock. This tuber is eagerly sought after by water fowl. A third method of wintering is by means of hibernacula. *Utricularia* is the best example of this. Toward the fall the tips of the branches, instead of elongating, cease growth, and the leaves are crowded into large, compact buds. When the plant dies on the advent of cold weather, these buds sink to the bottom, where they remain until spring. The winter buds of certain *Potamogetons*

[1] Kolpin Ravn, F. Om Flydeevnen hos Froene af vore Vand og Supplanter. Bot. Tidsskrift, vol. 19, pp. 143–177, 26 fig

are of this nature, and *Myriophyllum* also passes the winter in this way. Winter buds were common on three species of narrow-leaved *Potamogetons*, *P. zosteraefolius*, *P. pusillus*, and *P. freisii* (pl. 15, fig. 2). *Potamogeton lonchites* sometimes propagates by means of short branches, which produce buds at their ends. Roots and leaves grow out from these buds, and the result is a small plant, ready to root and grow whenever it is detached from the parent plant.

ANALYSIS OF SOIL SAMPLES.

The samples of soil collected at Put-in Bay, East Harbor, and Sandusky Bay were analyzed by the Division of Soils, U. S. Department of Agriculture. The results of the analyses are given in Table I. The number of samples is not sufficient to make general deductions possible, and therefore I shall merely indicate the direction in which the results seem to point, leaving it to future work to establish the relation, if any exists, between the texture of the soil and the plants growing upon it.

By reference to Table I, it will be seen that, as a rule, the soils on which plants occurred in abundance were composed largely of fine sand and very fine sand, and contained relatively little silt, fine silt, and clay, while the soils on which few or no plants occurred, although the depth of water and other physical conditions were favorable, were composed largely of silt, fine silt, and clay, and were poor in fine sand and very fine sand. The other items are of no practical importance, the amounts of gravel, coarse sand, and medium sand being very small, while the amount of organic matter is not at all regular, being relatively large in all samples from places where no plants grew and irregular in the other samples. Of all the samples taken, six must be excluded from the comparisons on account of other factors coming prominently into play. Sample 1, from Gibraltar Bar, is not comparable with the others, both on account of its mixed character and the exposed position of the bar, and the three samples from the open lake, Nos. 3, 4, and 7, were taken at a depth of 33 to 36 feet, and hence can not be compared with samples taken at depths not exceeding 7 feet. The two samples, 11 and 12, collected on the lake shore, were taken to determine the cause of the presence or absence of *Scirpus*. All the other samples, ten in number, were taken from places where the depth of water ranged from 6 inches to 7 feet, and where all the other physical conditions were nearly similar. I have, therefore, divided these ten samples into two sets, six in one and four in the other, and have added together for each sample the percentages of fine sand and very fine sand to make the first column of Table II, and the percentages of silt, fine silt, and clay to make the second column. The six samples of the first set represent localities well stocked with plants, while the four samples of the second set were taken from bottoms either bare or on which but a few plants were growing.

The agricultural value of soils is largely determined by their power to retain water—sandy, dry soils being good for early truck crops, but almost useless for the heavier late crops, as wheat or corn; while soils containing much clay retain water better and are consequently later and colder but more valuable for wheat and grass crops. As shown in pl. 2, Bulletin No. 5, Division of Agricultural Soils, a typical truck land contains 79.69 per cent of medium, fine, and very fine sand and 14.36 per cent of silt, fine silt, and clay. It is somewhat similar, therefore, to the sample of

the first group on which the heaviest growth was found (No. 2), the greatest difference being in the fact that in truck lands the percentage of medium sand is large while in our sample it is insignificant. The samples on which practically no plants were found are more uniform in texture than those of the first group and very much resemble the typical wheat lands, as given in plate 3, Bulletin 5, in which the percentage of fine sand and very fine sand is 36.90 and that of silt, fine silt, and clay 55.91.

The water in sandy soils is undoubtedly better aerated than that in clay soils, though both are under water, because in the former case the water passes through the soil more rapidly than it does in the latter, and it would seem that even the roots of aquatics are unable to thrive in a soil so poor in oxygen as the saturated heavy clays.

It will be necessary in future work to take many samples of the bottom under all conditions of vegetation and to take the temperatures not alone of the water but of the soil in which the plants are growing. A large series of such samples would make possible general conclusions that might be of practical value.

TABLE I.—*Mechanical analyses of soil samples taken from bottom of Put-in Bay and vicinity.*

Division No.	Locality.	Collection No.	Vegetation.	Moisture in air-dry sample.	Organic matter.	Gravel (2–1 mm.).	Coarse sand (1–0.5 mm.).	Medium sand (0.5–0.25 mm.).	Fine sand (0.25–0.1 mm.).	Very fine sand (0.1–0.05 mm.).	Silt (0.05–0.01 mm.).	Fine silt (0.01–0.005 mm.).	Clay (0.005–0.0001 mm.).
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
3852	Near West Harbor	11	Scirpus pungens.	0.14	0.88	0.20	0.22	0.78	83.70	12.80	0.35	0.07	0.65
3853	do	12	do	0.21	1.99	1.40	1.59	3.82	67.11	23.82	0.38	0.12	0.75
3847	Mouth of East Harbor	5	Good	0.88	3.68	0.00	0.00	0.38	74.15	18.65	1.04	0.31	1.86
3858	Edge of water near swamp	17	Fair	0.40	1.15	0.00	0.02	0.09	11.42	82.50	1.72	0.67	2.55
3857	Upper Sandusky Bay	16	Very good	0.74	2.02	0.00	0.05	0.12	20.66	63.56	5.64	1.52	5.85
3844	Southeast of Gibraltar Bar	2	Excellent	0.26	4.52	0.67	1.64	6.36	38.45	35.90	3.36	2.35	8.10
3851	Portage River	10	Good	2.54	7.07	0.00	0.00	0.68	4.70	62.00	9.51	2.92	12.55
3848	East Harbor	6	do	2.80	7.79	0.00	Trace.	0.48	21.58	38.65	7.53	4.68	17.13
3843	On Gibraltar Bar	1	Scant	1.56	6.26	7.73	7.13	14.20	12.15	8.59	16.58	6.09	21.60
3850	Portage River, broad part	9	Nothing	3.13	8.19	0.00	0.00	Trace.	1.86	27.46	24.37	7.63	27.39
3854	Upper Sandusky Bay	13	do	2.47	7.76	0.35	0.00	0.12	2.13	35.73	16.85	6.68	28.11
3855	1,000 feet from swamp	14	Very scant	2.34	6.45	0.00	0.29	Trace.	2.40	29.60	21.75	7.95	28.23
3856	Near Winona Point Clubhouse, Sandusky Bay.	15	do	3.62	7.23	0.00	0.00	Trace.	1.10	30.43	19.76	7.99	28.46
3845	Near fish hatchery in open lake.	3	Nothing	2.88	5.76	0.19	0.48	1.35	19.15	15.78	19.54	7.62	29.00
3846	In open lake	4	do	2.26	5.65	0.05	0.17	0.37	1.65	20.61	29.21	9.20	32.50
3849	East point of Middle Bass Island, open lake.	7	do	1.63	7.46	0.21	0.41	0.86	2.77	16.77	26.06	9.33	36.10

TABLE II.—*Comparison of samples collected at Put-in Bay and vicinity, with typical truck and wheat soils.*

Division No.	Collection No.	Depth in feet.	Condition of vegetation.	Per cent of medium sand, fine sand, and very fine sand.	Per cent of silt, fine silt, and clay.	
3847	5	1 to 2	Good	93.18	3.21	Set I.
3858	17	.5 to 1	Fair	94.01	4.94	
3857	16	3.5	Very good	84.34	12.99	
3844	2	7	Excellent	80.71	13.81	
3851	10	3	Good	67.38	25.08	
3848	6	3 to 4	do	60.71	29.34	
Early truck soil. Plate 2, Bull. 5, Division of Agricultural Soils				79.69	14.37	
3850	9	6	Nothing	29.39	59.39	Set II.
3854	13	6	do	37.98	51.64	
3855	14	5	Very scanty	32	57.93	
3856	15	6	do	31.53	56.21	
Wheat soil. Plate 3, Bull. 5, Division of Agricultural Soils				38.07	55.91	

Alphabetical list of plants occurring in Lake Erie and in swamps in the vicinity of Put-in Bay, Sandusky, East Harbor, and Portage River, Ohio.[1]

PHANEROGAMS.[2]

Acorus calamus L. East Harbor.
* *Alisma plantago* L. Portage River.
Apocynum cannabinum L. With *Scirpus pungens* in shallow water, West Harbor.
Asclepias incarnata L. Everywhere in very shallow water or on exposed muddy banks.
Bidens beckii Torr. Pond in East Harbor and in Squaw Harbor.
Boltonia asteroides L'Her. With *Scirpus pungens* in shallow water near West Harbor.
* *Brasenia schreberi* J. F. Gmel. Cedar Point.
* *Carex aquatilis* Wahl. Cedar Point, Sandusky.
Carex pseudo-cyperus var. *comosa* Boott. Squaw Harbor. Seen only in one place.
Carex stricta Lam. Pond on South Bass Island near hatchery.
* *Carex torta* Boott. Cedar Point, Sandusky.
Ceratophyllum demersum L. Everywhere.
Cyperus erythrorhizos Muhl. Muddy shores, Upper Sandusky.
Cyperus strigosus L. Upper Sandusky Bay.
Deyeuxia canadensis Munro. Muddy banks, East Harbor.
Dianthera americana L. Squaw Harbor, Put-in Bay, and East Harbor.
* *Eleocharis acicularis* R. Br. Cedar Point.
Eleocharis intermedia Schultes. Cedar Point.
Elodea canadensis Michx. Common.
Eupatorium perfoliatum L. With *Scirpus pungens* in shallow water, Squaw Harbor.
* *Fimbristylis autumnalis* R. S. Cedar Point.
Heteranthera graminea Vahl. Everywhere. One of the most common submersed aquatics. Found on mud flat at Portage River.
Hibiscus moscheutos L. East Harbor on muddy banks.
Ilysanthus riparia Rafin. Upper Sandusky Bay.
* *Juncus balticus* Willd. Cedar Point, Sandusky.
* *Juncus brachycephalus* (Engelm.) Buch. West Harbor.
Juncus torreyi Coville. Squaw Harbor in shallow water and on mud banks.
Leersia oryzoides Sw. With *Scirpus pungens*, West Harbor.
Lemna minor L. In ponds on South Bass Island and at East Harbor.
Lemna polyrhiza L. Common.
Lemna trisulca L. Pond on South Bass Island.
Lippia lanceolata Michx. Upper Sandusky Bay.
Mentha canadensis L. Muddy banks, Upper Sandusky Bay.
Myriophyllum spicatum L. Everywhere in quiet water, 2 to 4 feet deep.
Naias flexilis Rost. & Schmidt. Common.
Naias flexilis robusta Morong. More common than the species.
Naias gracillima Morong. Pond in Portage River swamp near Port Clinton.
Nasturtium palustre D. C. Muddy banks, Upper Sandusky Bay.
Nelumbium luteum Willd. Abundant at East Harbor, Portage River, and head of Sandusky Bay. Introduced into Squaw Harbor and near fish-hatchery.
Nuphar advena Ait. Common.
Nymphæa tuberosa Paine. East Harbor in 3 or 4 feet of water.
Phalaris arundinacea L. East Harbor, on mud banks.
Phragmites communis Trin. East Harbor. Forms extensive associations.
Physostegia virginiana Benth. Muddy bank, in Upper Sandusky Bay.
Polygonum muhlenbergii S. Wats. East Harbor and Sandusky Bay.
Polygonum acre H. B. & K. Muddy shores, Upper Sandusky Bay.
Populus monilifera Ait. Beach at East Harbor.
Potamogeton amplifolius Tuckerman. Near fish-hatchery and in Sandusky Bay. Not found with floating leaves.
Potamogeton foliosus Raf. Put-in Bay.
Potamogeton freisii Ruprecht. Put-in Bay. Not abundant.
Potamogeton heterophyllus Schreb. Gibraltar Bar, East Harbor, and Sandusky Bay. Floating leaves on specimens from Sandusky Bay.
* *Potamogeton hillii* Morong. East Harbor.
* *Potamogeton interruptus* Kitaibel. Sandusky Bay.
Potamoge'on lonchites Tuckerman. Put-in Bay, East Harbor, Sandusky Bay. One of the commonest species.
Potamogeton lucens L. East Harbor and Sandusky Bay.
Potamogeton filiformis Pers. Gibraltar Bar.
Potamogeton natans L. Put-in Bay, East Harbor.
Potamogeton pectinatus L. Everywhere. Extremely variable in size and habit.
Potamogeton perfoliatus L. Everywhere.
Potamogeton perfoliatus richardsonii A. Bennett, Put-in Bay.
Potamogeton prælongus Wulf. Portage River.
Potamogeton pusillus L. Put-in Bay, East Harbor.
Potamogeton robbinsii Oakes. East Harbor, Sandusky Bay.
Potamogeton zizii Roth. Sandusky Bay.
Potamogeton zosteræfolius Schum. Everywhere.
Ranunculus divaricatus Schrank. Sandusky Bay.
Rumex verticillatus L. Pool on South Bass Island.
Sagittaria arifolia Nutt. Muddy shore, Upper Sandusky Bay.
Sagittaria graminea Michx. Muddy shore, Upper Sandusky Bay.
Sagittaria latifolia Wild. Squaw Harbor, East Harbor.
Sagittaria rigida Pursh. Everywhere.
Salix longifolia Muhl. East Harbor. Frequently in several inches of water on the beach.
Salix nigra Marsh. East Harbor, on sand bar in 4 to 10 inches of water.

[1] Species marked with an asterisk were found in the herbarium of E. L. Mosely, of Sandusky, Ohio, and were not observed by me.

[2] Nomenclature generally according to Index Kewensis.

Alphabetical list of plants occuring in Lake Erie and in swamps in the vicinity of Put-in Bay, Sandusky, East Harbor, and Portage River, Ohio—Continued.

PHANEROGAMS—Continued.

Salix wardii Muhl. East Harbor. Sometimes in shallow water.
Scirpus atrovirens Muhl. Muddy banks, East Harbor.
Scirpus pungens Vahl. Everywhere.
Scirpus eriophorum Michx. Shallow water, Upper Sandusky Bay.
**Scirpus erectus* Poir. East Harbor.
Scirpus fluviatilis A. Gray. Everywhere.
Scirpus lacustris L. Everywhere.
Scirpus sylvaticus L. Shore of pool on South Bass Island.
**Scirpus torreyi* Olney. East Harbor.
Scutellaria galericulata L. East Harbor swamps.
Sium cicutæfolium Gmel. East Harbor swamps.
Sparganium curycarpum Engelm. Everywhere.
Spartina cynosuroides Willd. Upper Sandusky Bay.
Stachys aspera Michx. Borders of pool on South Bass Island.
Typha angustifolia L. Rare, along Portage River and Upper Sandusky Bay.
Typha latifolia L. Everywhere.
**Utricularia gibba* L. Cedar Point, Sandusky Bay.
Utricularia vulgaris L. East Harbor, Portage River.
Vallisneria spiralis L. Everywhere.
Wolffia columbiana Karst. Abundant in pool on South Bass Island.
Zannichellia palustris L. Squaw Harbor.
Zizania aquatica L. East Harbor, Portage River, Upper Sandusky Bay.

CHARACEÆ.[1]

Chara contraria A. Br., forma *gymnotiles* (No. 2). Abundant in Hatchery Bay, the common species.
Chara contraria A. Br., forma *paragymnophylla* (No. 17). This was identified with a doubt by Dr. Norstedt. The form is rare in Put-in Bay, growing in only one spot near Gibraltar Island, in 7.5 feet of water. It is so peculiar that a brief description will be given. Fruiting plants 5 to 10 cm. high; mostly with incomplete cortication, one plant of the collection being fully corticated, some not corticated at all, others with one or two joints of the leaves corticated; in these cases the second and third leaf joints are corticated with eight cells. Stipular whorl inconspicuous but double. Stipules short, less than one-half to one-third length of carpogone. End segment of leaf either obtuse and 1-celled or acute and 2-celled.
Chara contraria A. Br., forma (28). On sandy beach at East Harbor, Ohio. (Pl. 17, fig. 2.)
Chara contraria A. Br. (29). A low-growing delicate form found with 28, but having longer stipules and dwarfer habit.
Chara contraria A. Br. forma *subinermis* (30). Found with 28 and 29. Very dwarf habit; leaves much longer than the internodes and cortication imperfect; identified by Dr. Norstedt. No. 66, identified by Dr. Allen as belonging to this species and form, was collected on a clay bank in Squaw Harbor; water 6 to 12 inches deep. (Pl. 17, fig. 1.)
Chara contraria A. Br. (62). Very small specimens with extremely long leaves; collected in Lake Erie a mile outside of Sandusky Bay and in 6 to 8 feet of water.
Chara contraria A. Br. (68, 69, 70). In Put-in Bay.
Chara contraria A. Br. forma *elongata, macroptila, macrotiles, gymnotiles* (72). Put-in Bay.
Chara coronata Ziz. forma *microptila, incrustata* (23). Dr. Allen says this is a very unusual form with very short bracts. (Pl. 20, fig. 5.)
Chara coronata Ziz. (41, 42). East Swamp and East Harbor. (Pl. 20, figs. 1, 2.)
Chara coronata Ziz., forma *meiocarpa, meioptila* (32). On sandy beach, East Harbor. (Pl. 20, fig. 4.)
Chara coronata Ziz., forma *incrustata* (74). Clay bank in shallow water, Squaw Harbor. (Pl. 20, fig. 3.)
Chara sejuncta A. Br. (31). On Sandy beach, East Harbor.
Chara gymnopus var. *michauxii* A. Br. (53). On mud bottom in shallow water, Portage River. (Pl. 19, fig. 1.)
Chara fragilis Desv., forma *brevibracteata* (33). East Harbor, Ohio. (Pl. 16, fig. 2.)
Chara fragilis Desv., forma *subinermis* (36). Put-in Bay.
Chara hydropitys Reichenbach, forma *compacta* (65). On clay bank in very shallow water, Squaw Harbor. (Pl. 17, fig. 3.)
Chara aspera (Dethard) Willd. (67). On clay bank in very shallow water, Squaw Harbor. This species was not found in fruit.
Chara intermedia A. Br. (71 probably) (73). Both in Put-in Bay.
Nitella subglomerata A. Br. On sandy beach at East Harbor (75). (Pl. 18, fig. 3.) In mud with *Chara gymnopus michauxii*, Portage River. (55). (Pl. 18, fig. 1.)
Nitella polyglochin A. Br. (26). With other Characeæ on sandy beach at East Harbor. (55). (Pl. 19, fig. 2.)
Nitella batrachasperma (Reichenbach) A. Br. (27). On sandy beach East Harbor and on mud bottom in Portage River.
Nitella tenuissima Desv. (27½). Two specimens of 27 were sent to Dr. Allen, and they were thought to belong to the same species. It appears, however, that one was *N. batrachasperma* and the other, which Dr. Allen numbered 27½, was *N. tenuissima*. The one sent to Dr. Nordstedt as 27 was *N. tenuissima*.
Nitella gracilis Ag. vel sp. *affinis* (64). Upper Sandusky Bay, in quiet water. Immature.
Tolypella intertexta Allen (No. 1). Occurs in Hatchery Bay, but the plants are nowhere thrifty. July.

[1] The Characeæ were kindly determined by Dr. T. F. Allen and Dr. Otto Nordstedt.

Alphabetical list of plants occurring in Lake Erie and in swamps in the vicinity of Put-in Bay, Sandusky, East Harbor, and Portage River, Ohio—Continued.

DESMIDIEÆ.

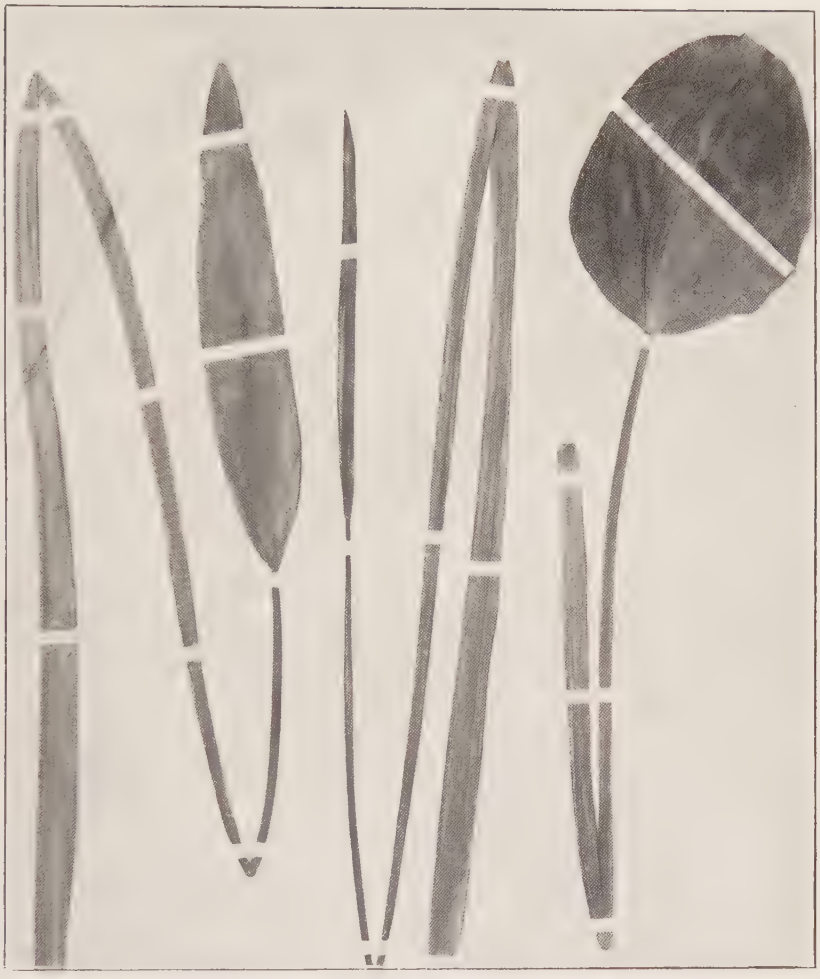
Closterium ehrenbergii Menegh. In tow, Put-in Bay.
Closterium leibleinii Kuetz. In washings from *Bidens beckii* and *Utricularia vulgaris*.
Closterium parvulum Naeg. In washings from *Bidens beckii* and *Utricularia vulgaris*.
Closterium venus Kuetz. In tow, Put-in Bay; in *Utricularia* washings and in pool on Starve Island.
Closterium dianæ Ehrenb. In washings from *Sagittaria rigida*, Squaw Harbor.
Cosmarium angulare Johnson. In *Utricularia* washings. Mr. Johnson described this species from material collected by myself at Lake St. Clair in 1893. It will probably be found at other points along the lakes.
Cosmarium botrytis Menegh. In tow, Put-in Bay, and nearly all plant washings.
Cosmarium brebissonii Menegh. Starve Island.
Cosmarium depressum Lund. Put-in Bay.
Cosmarium granatum Breb. In *Utricularia* washings.
Cosmarium læve Rabenh. In washings from *Enyconema* and *Sagittaria*.
Cosmarium margaritiferum Menegh. In *Utricularia* washings.
Cosmarium meneghinii Breb. In *Utricularia* washings.
Cosmarium moniliforme Ralfs. In *Bidens beckii* washings.
Cosmarium nitidulum De Not. In washings from *Enyconema* and *Sagittaria*.
Cosmarium ornatum Ralfs. In *Bidens beckii* washings.
Cosmarium portianum Archer. In *Utricularia* washings,
Cosmarium punctulatum Breb. In tow and in washings from various plants.
Cosmarium reniforme Archer. In tow and in washings from various plants.
Cosmarium reniforme var. *compressum* Nordst. Put-in Bay.
Desmidium swartzii Breb. Put-in Bay.
Disphinctium connatum (Breb.) De Bary. Put-in Bay.
Euastrum elegans Kuetz. In *Bidens beckii* washings.
Euastrum binale Ralfs. In washings from *Bidens beckii* and *Utricularia vulgaris*.
Euastrum elegans var? In *Utricularia* washings.
Gonatozygon kinahani (Archer) Rabenh. In *Bidens beckii* washings.
Gonatozygon ralfsii De Bary. In *Bidens beckii* washings.
Hyalotheca dissiliens Breb. In *Utricularia* washings.
Hyalotheca mucosa Ehrenb. In *Bidens beckii* washings.
Pleurotæniopsis ralfsii (Breb.) Lund. In *Utricularia* washings.
Pleurotænium trabecula (Ehrenb.) Naeg. In *Utricularia* washings.
Staurastrum avicula Breb. In *Utricularia* washings.
Staurastrum brebissoni Archer. In *Utricularia* washings.
Staurastrum crenulatum (Naeg.) Delponte. In *Utricularia* washings.
Staurastrum dejectum Breb. In tow, Put-in Bay.
Staurastrum dilatatum Ehrenb. In *Utricularia* washings.
Staurastrum furcigerum Breb. In *Utricularia* washings.
Staurastrum punctulatum Breb. In tow, Put-in Bay.
Staurastrum striolatum Archer. In *Sagittaria* washings.
Staurastrum tetracerum (Kuetz.) Ralfs. In *Bidens beckii* washings.
Xanthidium antilopæum Kutz. In *Utricularia* washings.

1. SPARGANIUM EURYCARPUM, ROOTSTOCK.

2. SCIRPUS LACUSTRIS, ROOTSTOCK.

3. POTAMOGETON HETEROPHYLLUS.

4. JUNCUS TORREYI, ROOTSTOCK.

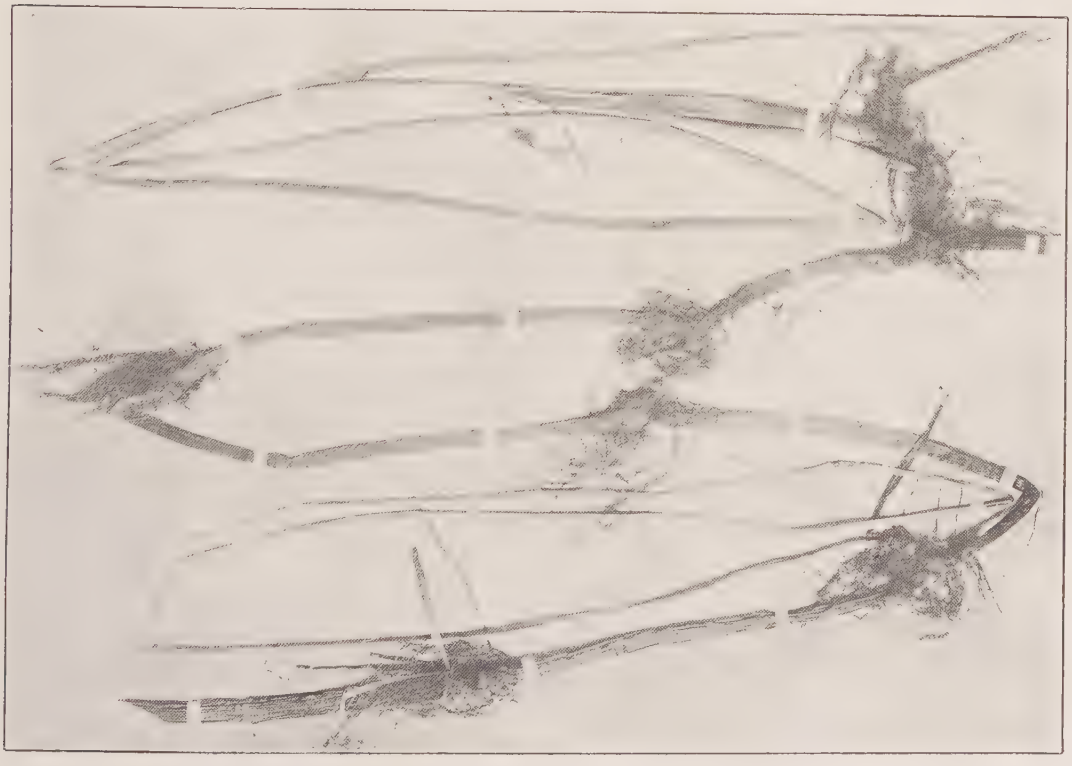


1. SAGITTARIA RIGIDA.

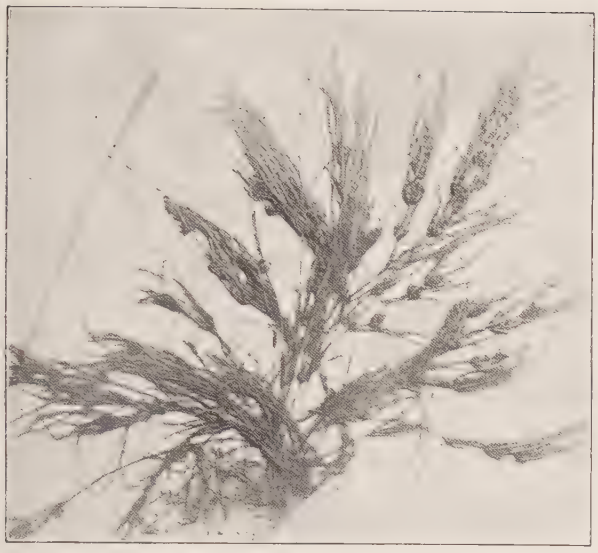
The leaf in the center is from deep water; that at the right from shallow water near the shore.

2. WINTER BUDS: POTAMOGETON ZOSTERÆFOLIUS AT THE LEFT; P. PUSILLUS, UPPER RIGHT; P. FREISII, LOWER RIGHT.

2. CHARA FRAGILIS FORMA BREVIBRACTEATA.

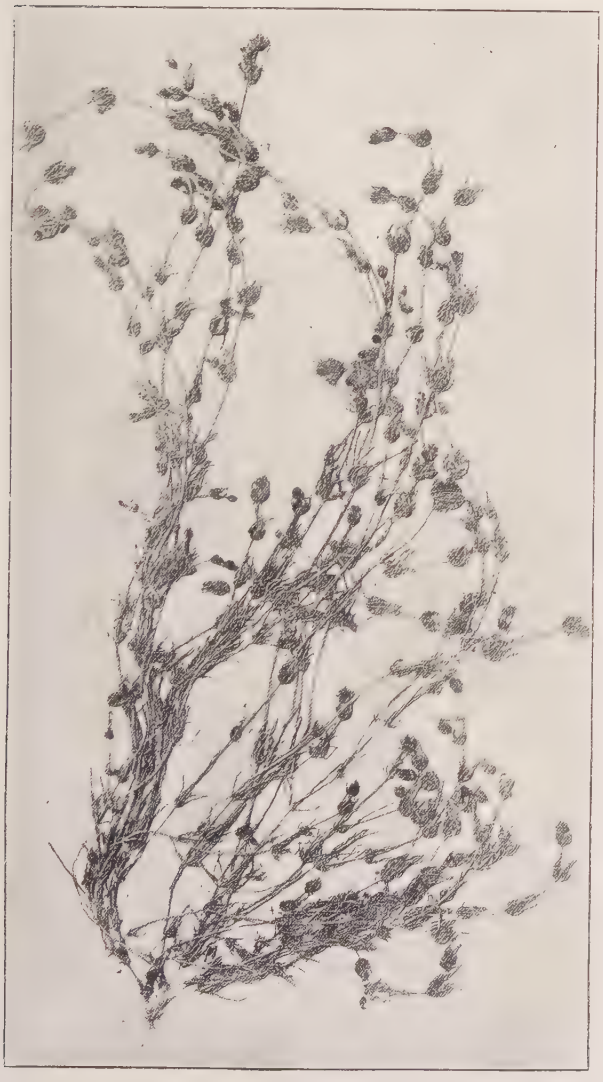


1. SCIRPUS PUNGENS, ROOTSTOCK.



1. CHARA CONTRARIA FORMA SUBINERMIS.

3. CHARA HYDROPITYS.



2. CHARA CONTRARIA.

4. TYPHA LATIFOLIA, ROOTSTOCKS.

5. NUPHAR ADVENA, ROOTSTOCK.

1. NITELLA SUBGLOMERATA. MUD BOTTOM.

2. NAIAS FLEXILIS.
Dwarf compact form growing on surf-beaten shore.

3. NITELLA SUBGLOMERATA. SANDY BEACH.

1. CHARA GYMNOPUS MICHAUXII, SHOWING RUNNERS.

2. NITELLA POLYGLOCHIN

1. CHARA CORONATA.

On mud bottom in shallow water.

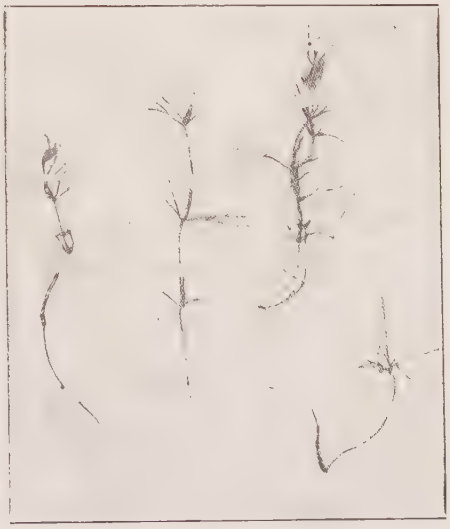
3. CHARA CORONATA.

From shallow water in Squaw Harbor.

4. CHARA CORONATA

In shallow water on sandy beach.

2. CHARA CORONATA, TYPICAL FORM.



5. CHARA CORONATA.

An anomalous form from Put-in Bay growing at the bottom of 7 feet of water.

THE LEPTOCEPHALUS OF THE AMERICAN EEL AND OTHER AMERICAN LEPTOCEPHALI.

By CARL H. EIGENMANN and CLARENCE HAMILTON KENNEDY.

It is an anachronism to describe "species" of *Leptocephali*, since Gill, Delage, Gilbert, and Grassi have definitely traced various "species" to their adult forms. Nevertheless this is what we have done. Our excuse is that with but two exceptions we have not been able to connect any of the forms examined with their adult stage. It may take many years to complete the series demonstrating the life history to which each of the species described belongs, and in the meanwhile it will be advantageous to have definite forms placed on record for the benefit of all who may secure *Leptocephali* and may not be within reach of the specimens examined.

In preparing this account we have found Strömman's "Leptocephalids in the University Museum at Upsala" of great value. It is unfortunate that Strömman neglected to count the segments, since Grassi has demonstrated that this is one of the characters in which a *Leptocephalus* agrees with its adult form.

Several of the species to be described here are of great interest. One of these is the *Leptocephalus* of the American eel, *Anguilla chrysypa*. We have taken pleasure in associating the name of Grassi with this species in recognition of his identification of *Leptocephalus breviceps* with the European eel. Incidental to the identification of the *Leptocephalus* of the American eel, we have found that the American eel has but 105 to 110 segments, several less than the European eel possesses. Another interesting species is *Leptocephalus diptychus*, in which the color of each side is asymmetrically arranged as to the distance between successive spots, but the blending of the color of the two sides of the transparent creature gives the effect of symmetrically arranged markings.

Most of the species described here are new and belong unquestionably to different adult forms. Concerning others we are not at all certain whether the species belong to different adult eels or are different stages of the same eel. Thus we are not certain whether *L. amphioxus* and *L. rex* are different stages of the same form or not. The same is true of *L. gillii* and *L. latus*.

The name *Leptocephalus* was originally proposed in 1777 for *L. morrisii*, the larva of the conger eel. Since this name is older than any other that has been applied to the adult conger, it has recently been appropriated by Jordan & Evermann (Fishes of North and Middle America, p. 353) for the conger eel. This leaves us without a distinct appellation for larval eels of the *Leptocephalus* type. It might be advantageous to use the second name proposed for a larval eel, if the possibility of losing it as soon

as the adult form was determined did not stare us in the face. We have, therefore, retained the name *Leptocephalus* for the larvæ.

The specimens forming the basis for this paper belong to the U. S. National Museum. We wish to express our thanks to the authorities for the privilege of examining them. Most of them were collected by the Fish Commission steamer *Albatross* at the following stations:

Date.	Station No.	Lat. N.	Long. W.	Approximate location.
1883.		° ′ ″	° ′ ″	
Nov. 5	2103	38 47 20	72 37 00	100 miles SE. Atlantic City, N. J.
1885.				
Aug. 29	2566	37 23 00	68 08 00	250 miles SE. Nantucket.
Sept. 3	2575	41 07 00	65 26 30	160 miles S. Cape Sable, Nova Scotia.
Sept. 20	2588	39 02 00	72 36 00	95 miles E. by S. Long Branch, N. J.
Oct. 17	2596	35 08 30	75 10 00	20 miles SE. Cape Hatteras.
Oct. 18	2597	34 57 00	75 43 30	20 miles S. Cape Hatteras.
Oct. 18	2600	34 39 30	75 35 30	40 miles S. Cape Hatteras.
Oct. 19	2611	34 15 00	76 11 30	55 miles SSE. Cape Lookout.

Other localities will be given with different specimens.

Grassi has demonstrated that the *Leptocephali* possess as many segments as the adult and we have found that the number of segments in the different specimens of a given *Leptocephalus* varies but little. The following table of the *Leptocephali*, arranged according to the number of segments, may therefore assist in referring these species to their other larval phases and adult forms. It will also serve as a key to the species described and permit other species that may be discovered to be readily interpolated:

Species.	Length.	Protovertebræ.		Total.
		Abdominal.	Caudal.	
	mm.			
Leptocephalus grassii	47	65	40	105
	49	68	40	108
Leptocephalus diptychus	38	76	38	114
	51	73	43	116
Leptocephalus rex	87	59	60	119
	100			123
Leptocephalus amphioxus	65	102	20	122
Leptocephalus caudomaculatus	42	71	57	128
	54	70	58	128
	57	71	56	127
	59	72	58	130
Leptocephalus latus	70	98	35	133
Leptocephalus gillii	50	96	41	137
Leptocephalus strommani	61	70	71	141
Leptocephalus morrisii	71	54	88	142
	86*	69	73	142
Leptocephalus mucronatus	75	65	79	144
	80	66	80	146
	82	67	80	147
Leptocephalus discus	69	72	83	155
	71	75	84	159
Leptocephalus humilis	75	68	91	159
	76	69	93	162
	78	71	90	161
Leptocephalus gilberti	85	68	89	187
	73	100	80	180

*The larger specimen is the younger.

Several characters used in the following key have proved of but transient value. The approximation or separation of the nares we have found in one case to depend on the age of the specimen. The presence or absence of the pectorals we have also found to depend at times on the age of the specimen. Whether these two characters are ever of permanent value we are unable to say.

Key to the species of Leptocephali described in the present paper.

a. A series of three or four large conspicuous black spots on each side. Segments 114 to 116. Other characters differing greatly with age ..... *diptychus*

aa. Sides without large conspicuous black spots.

b. Pectorals none; nostrils remote.

c. Head depressed between the eyes; 96 abdominal, 40 caudal segments ..... *gillii*

cc. Head swollen between the eyes; a series of black dots along back and belly.

d. Anus near middle of length; eye large, 1.6 in snout; gradually tapering from snout to anus, thence decreasing gradually to the tail; no pigment about head, except in gular region; segments 70 + 71 ..... *strömmani*

dd. Anus much nearer tip of caudal than snout; eye small, 2.5 in snout; rapidly widening from nape to about the twenty-fifth segment, then of nearly uniform width to anus at ninety-eighth segment, thence tapering to tip of tail; pigment dots on top of head; segments 98 + 35 ..... *latus*

bb. Pectoral fins present.

e. Caudal suddenly contracted; head conical; eye small, 2.66 in snout; nostrils remote; segments 66 + 80 ..... *micronatus*

ee. Caudal not contracted, the vertical fins continuous with it.

f. Nostrils remote.

g. Snout obtuse, lower jaw the shorter.

h. No color along the middle of the sides. Segments about 60 + 60 ..... *rex*

hh. A series of spots along the middle of the side; another along the ventral margin; segments 54 + 88 (see also *n*) ..... *morrisii*

gg. Snout pointed, jaws equal.

i. Body short, elliptical; no pigment; tongue free in front; segments 68 + 40 ..... *grassii*

ii. Body elongate, band-shaped.

j. Eye 1.5 in snout; nostrils above the level of the middle of the eye; a series of rounded spots along the middle of the sides, one to each 2 to 3 segments; segments 72 + 83 ..... *discus*

jj. Eye 1.5 in snout; nostrils on level with middle of eye; tongue not free in front; a series of elongate spots along the middle of the sides, one to each segment; segments about 160 ..... *humilis*

ff. Nostrils approximated; body elongate, nearly band-shaped; a series of spots below the middle of the sides.

k. Vent near the posterior end of the body; color along sides consisting of a series of round chromatophores on the somites ..... *amphioxus*

kk. Vent near the middle of the body.

l. A series of spots in the tail just beneath the notochord; segments 127 to 130 ..... *caudomaculatus*

ll. No spots in the tail.

m. A series of chromatophores along the base of the dorsal rays; segments about 159 to 162 ..... *humilis*

mm. No chromatophores along the base of the dorsal rays.

n. Segments 142 ..... *morrisii*

nn. Segments 180 ..... *gilberti*

All drawings illustrating this paper were prepared by Mr. Clarence Hamilton Kennedy.

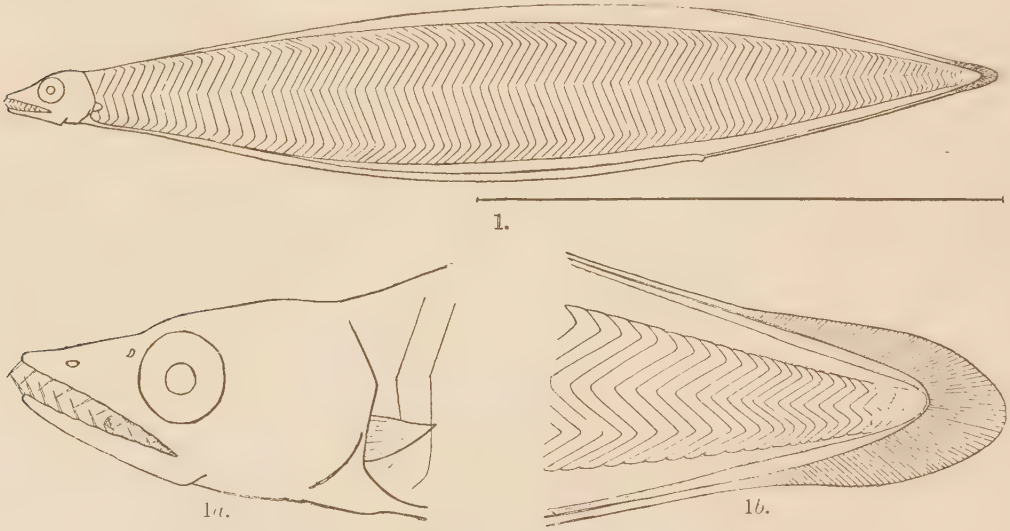
DESCRIPTIONS OF SPECIES.

Leptocephalus grassii, sp. nov. = **Anguilla chrysypa.** Figs. 1, 1*a*, 1*b*.

One specimen 47 mm. long, *Albatross* station 2103. One 49 mm. long, *Albatross*, lat. 38° 25′ N., 72° 40′ W.

This species is distinguished by its broad, well-developed vertical fins, deep and robust body, and absence of all pigment. Body lanceolate, sharp at both ends, deepest at the middle; its depth 5.66 in the length; dorsal beginning about 8 segments in front of anus, its rays becoming gradually longer to the caudal, whose rays are about 1 m. long; anal similar to the dorsal; pectoral well developed; head sharply conical, upper and lower profile equally slanting; eye large, 1.33 in snout, 4 in head; no pigment cells; segments 65 + 40 and 68 + 40.

This species very closely resembles *Leptocephalus breviceps*, which Grassi has shown to be the young of the European eel. The segments of the European eel are given as 116. The vertebræ of seven young eels taken at Woods Hole during the summer of 1900 range from 106 to 110, as follows: 35 + 71, 35 + 72, 36 + 71, 36 + 71, 36 + 73, 36 + 74, 42 + 65. This number agrees with the number of segments in *L. grassii*.



Leptocephalus grassii.

The close similarity of this species to *Leptocephalus breviceps*, the absence of color, the structure of the caudal, and the difference of this species from *breviceps* in just that character, viz, number of vertebræ, in which the American eel differs from the European eel, make it quite certain that the present species is the larva of the American eel.

We take pleasure in associating the name of Professor Grassi with the larva of the American eel.

Leptocephalus diptychus E. & K. Figs. 2, 2*a*, 2*b*, 2*c*, 2*d*, 2*e*.

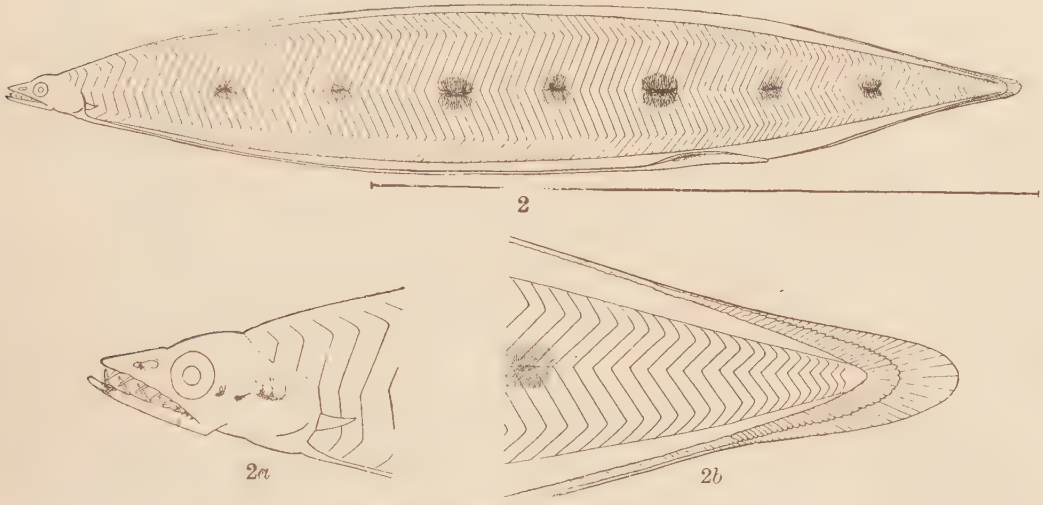
Leptocephalus diptychus, Eigenmann & Kennedy, Science, XII, p. 401. 1900.

Type, one specimen 38 mm. long, *Albatross* station 2566; surface, evening. Cotype, one specimen 51 mm. long, *Albatross*, New Providence; surface, electric light.

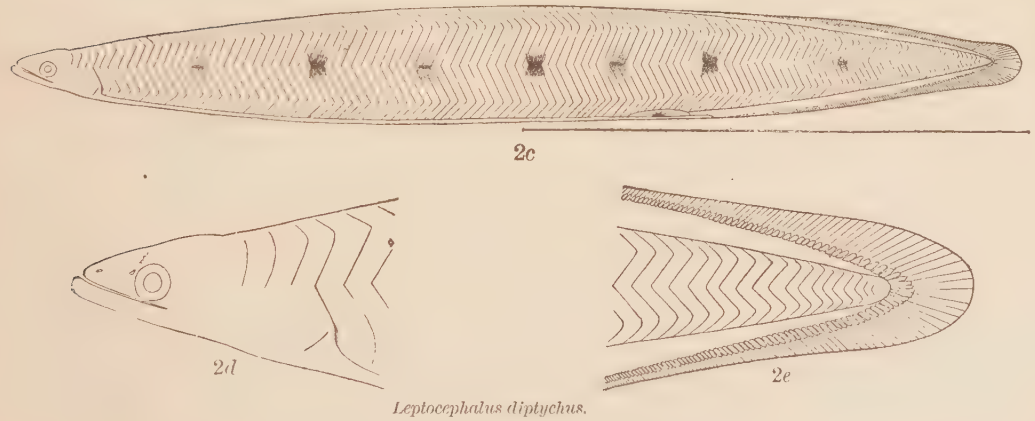
This species differs from all other species of *Leptocephalus* in the presence of eight large chromatophores, one in the alimentary canal a short distance in front of the anus, and seven along the middle line of the body, three of which are on the left side and four are on the right. Those of opposite sides alternate with each other, so that they appear in the translucent fish as a series of seven spots placed at more or less regular intervals along the side. Each one of the spots of the side consists of a large

chromatophore extending over three to four somites. At the margin of these larger chromatophores there are rarely minute chromatophores.

The two specimens differ from each other very greatly in the shape of the head, the nostrils, the development of the pectoral, and the shape of the body. The fact that the large one has lost its teeth and its head has assumed a distinct eel shape, together with the similarity of the structure of the caudal, the unique coloration, and the similarity in the number of myotomes, make it very probable that the two specimens are different stages of the same species.



Leptocephalus diptychus, small specimen.



Leptocephalus diptychus.

The two specimens differ as follows:

a. Body more elongate; pectorals a mere ridge; nostrils remote from each other for a distance nearly equal to the diameter of the eye; leptocephalous teeth wanting; lower jaw projecting, its tip rounded and entering the profile; no pigment spots about the head; depth 8.6; head distinctly more than half the depth of the body, nearly 11 in the length; eye 7 in head, 1.5 in snout; segments 73 + 43 ..... *type*

aa. Body elliptical; pectorals well developed; nostrils not yet separated; leptocephalous teeth; jaws nearly equal; a pigment spot near the end of the lower jaw, another within the anterior nares, two succeeding each other between the lower margin of the pupil and the lower margin of the auditory capsule; depth 6; head less than half greatest depth; eye 5 in head; segments 76 + 38 ..... *cotype*

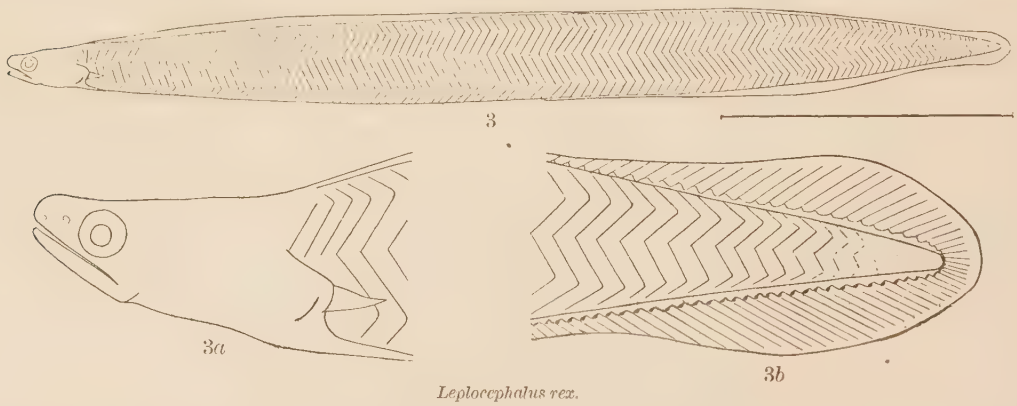
Details of the distribution of spots on the two sides of L. diptychus.

Younger specimen.		Older specimen.	
No. of segments between centers of successive spots.	Serial number of protovertebræ over which a spot extends. (R=right side, L=left.)	No. of segments between centers of successive spots.	Serial number of protovertebræ over which a spot extends. (R=right side; L—left.)
12	15, 16, 17 R	12	12, 13, 14 R.
	27, 28, 29 R		24, 25, 26 L.
13	40, 41, 42 L	12	36, 37, 38 R.
11	51, 52, 53 R	12	48, 49, 50 L.
11	62, 63, 64, 65 L	10	58, 59, 60 R.
14	76, 77, 78 R	13	71, 72, 73 L.
15	91, 92, 93 L	17	87, 88, 89, 90 R.

Leptocephalus rex, sp. nov. Figs. 3, 3*a*, 3*b*.

One specimen, 87 mm. long, *Albatross*, San Salvador, 1886. One 105 mm. long, *Albatross*, New Providence. The first specimen may represent a later phase of the species called *amphioxus*.

The head has taken on its adult form, the snout is rounded, the lower jaw is shorter than the upper, and the larval teeth have dropped out. The body is not as compressed as in true larval forms.



Leptocephalus rex.

The tail is long and pointed. The greatest depth is 11.5 in the length. The head is nearly 13 in the length. The dorsal begins a few segments in front of anus. The caudal is rounded, continuous with the high dorsal and anal. A series of color cells along base of anal and caudal rays; a few cells in deeper parts of tip of tail; no color elsewhere about body or head; segments 59 + 60.

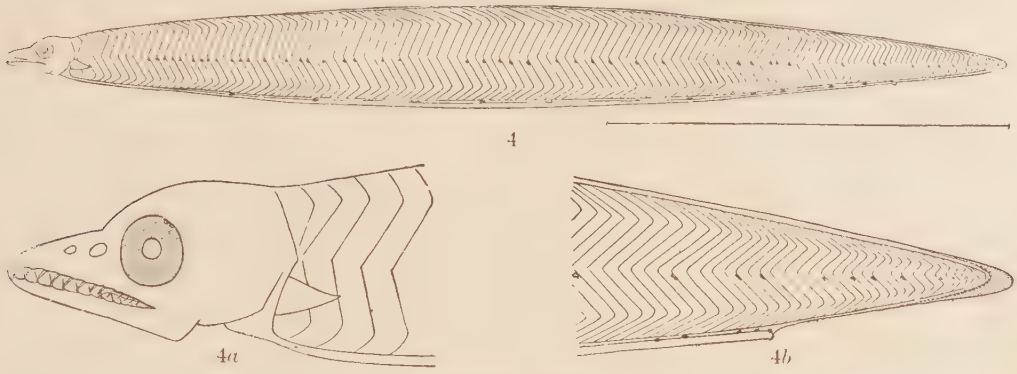
The second specimen differs from the one above described in having a series of spots along the base of the dorsal as well as the anal, and in having 123 segments. The difference in color may be due to difference in age. This specimen is much shriveled by alcohol.

Leptocephalus amphioxus, sp. nov. Figs. 4, 4*a*, 4*b*.

Type, one specimen, 65 mm. long, *Albatross*, lat. 38° 25′ N., long. 72° 40′ W.

This species is evidently very closely related to *Leptocephalus immaculatus* Strömman, from which it differs in the more pointed snout and tail and the presence of a series of chromatophores along the middle of the side. Body tapering nearly equally from both ends to the middle; depth about 9.5 in the length; head depressed in front of the eyes, snout pointed, jaws equal; eye 1.66 in snout, 4.4 in head; nostrils near together; head 14.5 in the length; pectorals well developed; alimentary canal extending to near the tip of the tail; caudal well developed, not separated from the dorsal and anal;

head without pigment, an irregular series of small round chromatophores on the somites near the middle of the body; a series of chromatophores at the base of the vertical fins, a series of chromatophores above the alimentary canal. Segments 102 + 20.

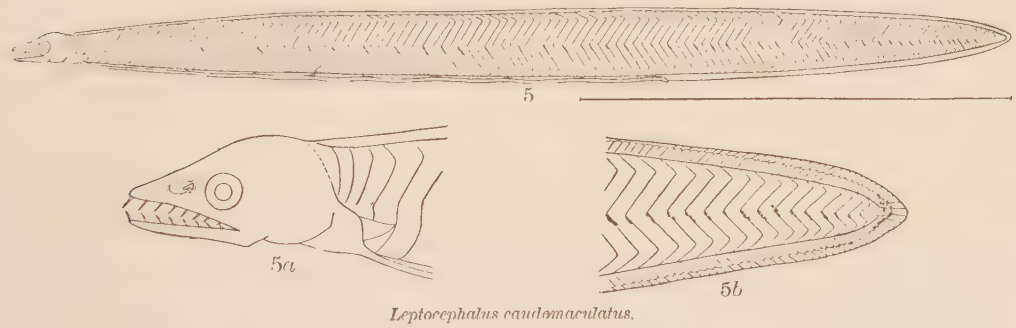


Leptocephalus amphioxus.

Leptocephalus caudomaculatus, sp. nov. Figs. 5, 5*a*, 5*b*.

Four specimens 42, 54, 57, and 59 mm. long. *Albatross* station 2597.

This species resembles *L. humilis* in most characters. It is most readily distinguished from that species by the absence of chromatophores along all but two or three of the dorsal rays. The rayed dorsal begins about the fourth segment in front of the anus. Greatest height 13 in the length. The body is nearly of uniform height from the head to beyond the alimentary canal. Head about 1.25 in the greatest height; eye 2 in snout, 5.5 in head; snout pointed; profile straight or slightly depressed over eyes; pectorals well developed; nostrils close together, anterior about half way between eye and tip of snout; one or two chromatophores at the margin of the upper jaw; no other chromatophores about



Leptocephalus caudomaculatus.

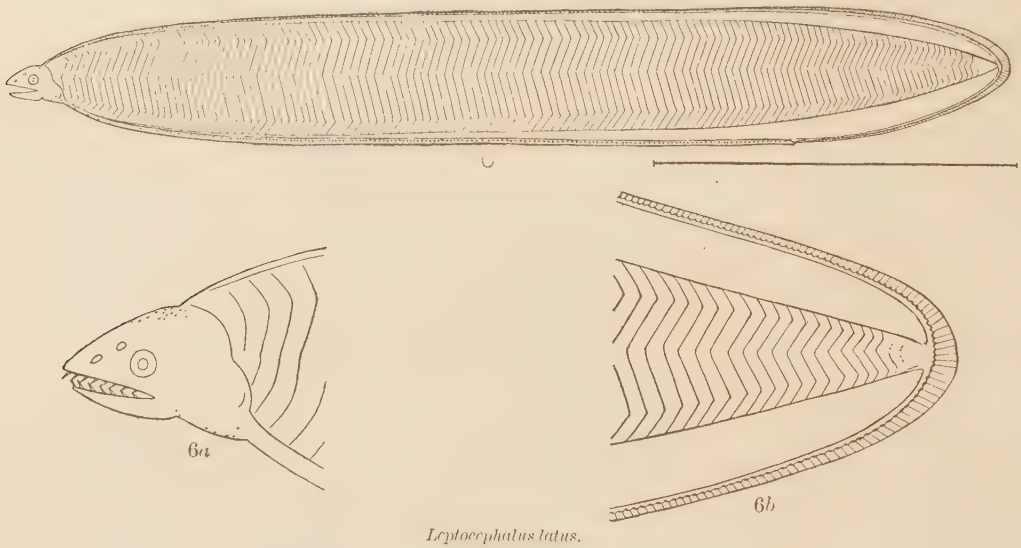
the head; a series of 9 pigment spots above the alimentary canal; no pigment spots at base of anal or dorsal; a few chromatophores at base of tail; a spot at the upper surface of the spinal cord at its end; a series of about four spots in the tail just beneath the notochord; the myocomma with 1 to 3 insignificant chromatophores below the median line; myotomes 70–72+56–58.

Leptocephalus latus, sp. nov. Figs. 6, 6*a*, 6*b*.

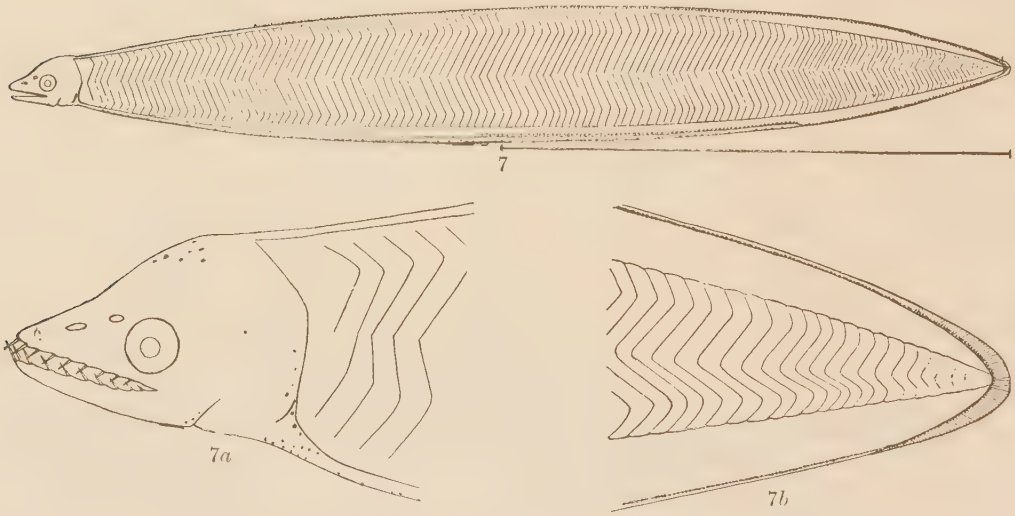
Type, one specimen 70 mm. long. *Albatross* station 2611; surface.

This species is evidently very closely related to *L. fulginosus* Strömman. It differs from the latter principally in the size of the eye and in pigmentation. Since his specimen was larger (78 mm.), the difference in the size of the eye is not attributable to age. Body very thin and elevated, rather suddenly widened at the nape and reaching its maximum height near the middle of the body, where it remains the same to near the anus, the tail broadly rounded; greatest height 7.4; head small, about 17

in the length; lower jaw distinctly shorter, leptocephalous dentition persisting; eye small, 2.5 in snout, 7 in head; nostrils remote; pectorals not developed; a few scattered pigment cells in the opercular region, a few cells on top of the head, a series of pigment cells along the base of the dorsal, anal, and ventral line, those along the bases of the fins forming a nearly complete line, those along the lower surface of the abdomen more widely separated; segments 98+35.



Leptocephalus latus.



Leptocephalus gillii.

Leptocephalus gillii, sp. nov. Figs. 7, 7*a*, 7*b*.

Type, one specimen 50 mm. long. *Albatross*, lat. 38° 25′ north, long. 72° 40′ west.

This species differ from *L. latus* in the shape of the head and body. The specimen is, however, somewhat shriveled, and the differences may be due to age and to preservation.

The body tapers gradually to the middle of the body; the tail is rather pointed; greatest height 7.5 in the length; eye 13.5 in the length; profile depressed between nostrils; jaws equal; distance

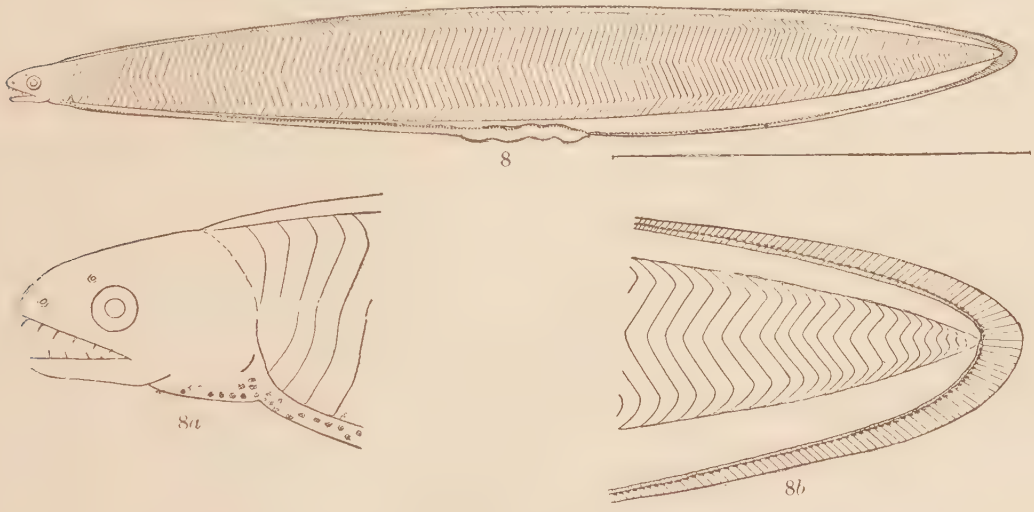
between nostrils about equal to pupil; eye 5.33 in head; pectorals none; a group of pigment cells on top of head and a similar group below gill opening, an irregular row of spots along ventral side of abdomen, a more regular row of smaller spots along base of dorsal and anal fins. Segments 96 + 41.

We take pleasure in associating with this species the name of Dr. Theo. Gill, the first to express the conviction (Proceedings Philadelphia Academy of Natural Sciences, 1864) that a *Leptocephalus* is the larva of an eel.

Leptocephalus strömmani, sp. nov. Figs. 8, 8*a*, 8*b*.

Type, one specimen 61 mm. long. *Albatross* station 2596.

This species is evidently closely related to *L. latus*. It differs from that species chiefly in the position of the anus and the folding of the posterior section of the alimentary canal. The body is not so deep nor so suddenly expanded behind the nape, tapering instead rather evenly in front and behind. Its greatest depth is near the anus and is 7.5 in the length, and the tail is rounded, without a distinct caudal, but with the middle rays longer than in *L. latus*. The head is about 15.5 in length. The lower jaw is distinctly shorter than the upper, the profile rounded; eye medium, about 5.5 in head, 1.6 in snout; nostrils remote by a distance about equal to the diameter of the eye; pectorals not developed;



Leptocephalus strömmani.

a group of pigment cells in the gular region; no other pigment cells about the head; a series of pigment cells around the edge of the body, those in the abdominal region above the alimentary canal, except along its anterior third, where they are along the ventral surface; no color on body. Segments 70 + 71.

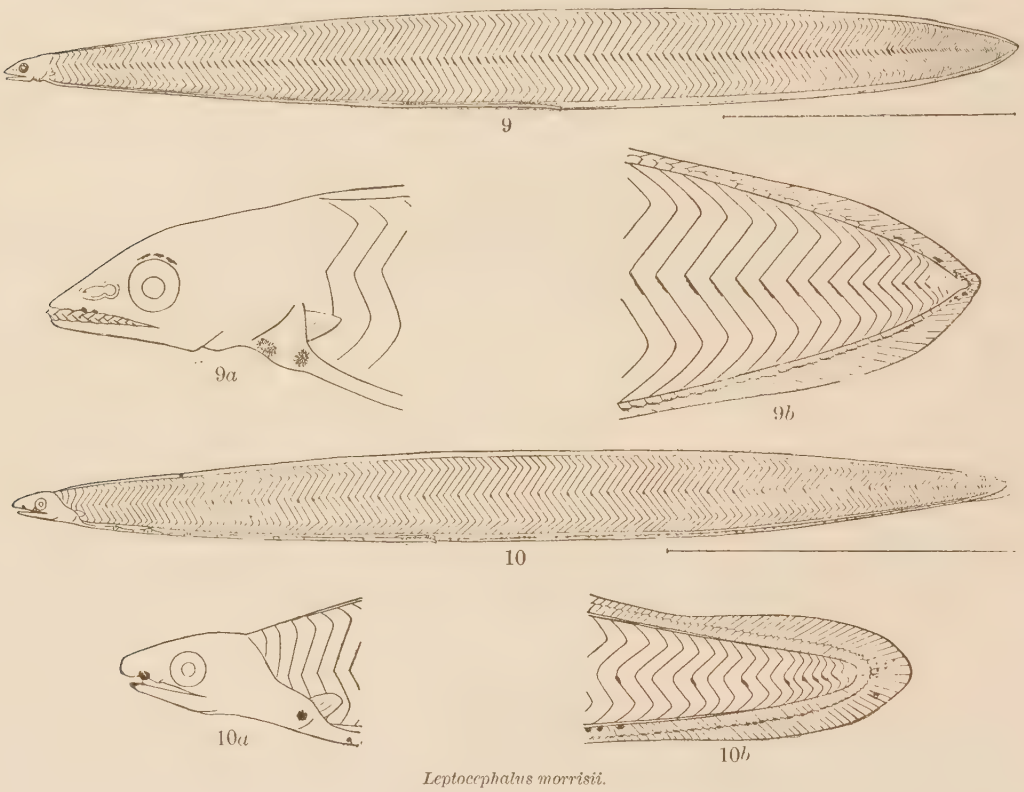
We take pleasure in dedicating this species to the author of "Leptocephalids in the University Zoological Museum at Upsala," Dr. Strömman.

Leptocephalus morrisii Scopoli = **Leptocephalus conger.** Figs. 9, 9*a*, 9*b*; 10, 10*a*, 10*b*.

One specimen 86 mm. long. *Albatross* station 2588.

Body gradually tapering from the head to behind the anus, where the depth is 10.33 in the length; fins very low; rayed dorsal beginning four segments in front of the anus; tail pointed; head pointed; jaws equal; profile nearly straight; eye 1.6 in snout, about 5 in head; nostrils approximated; pectoral well developed; three or four pigment cells over the eye; two chromatophores below the pectoral; a series of eight pigment spots above the alimentary canal; a pigment spot beneath the alimentary canal opposite the second one above; a row of pigment cells along the base of the anal, beginning about two segments behind anus and extending to caudal; several chromatophores at base of caudal and two at base of dorsal near tail; none at base of any other dorsal rays or along the back; sides with a series of linear spots on the myocomma beneath median line; segments 69 + 73.

A specimen 74 mm. long from New Providence (*Albatross*, surface), which has undergone a partial metamorphosis, seems to be referable to this species. The leptocephalous teeth have been lost, the snout has become rounded, and the alimentary canal shorter. Body long and band-shaped, tapering gradually from head to midway between caudal and anus; depth about 11 in length; head small, about 16 in length of body; snout rounded; lower jaw shorter than upper; mouth extending beyond eye; pectorals well developed; eye 1.5 in snout, about 5 in head; dorsal beginning in posterior fourth of alimentary canal, increasing in height to caudal; anal similar to dorsal; one or two chromatophores below pectoral; a series of six spots along alimentary canal, a few cells scattered between them; a series of spots along base of anal and caudal; a few spots on caudal and a few along the bases of last dorsal



Leptocephalus morrisii.

rays; sides with an irregular series of spots on the myocomma, each spot composed of from one to three chromatophores, which are expanded on surface over the myocomma rather than in them, as in the younger specimens; two minute chromatophores on one side of head.

Leptocephalus mucronatus, sp. nov. Figs. 11, 11*a*, 11*b*.

Specimen No. 1, 75 mm. long; No. 2, 80 mm. long; No. 3, 82 mm. long. *Albatross* station 2575, lat. 38° 25′ north, long. 72° 40′ west.

This species differs from all others in our collections, or in descriptions accessible to us, in its suddenly contracted or mucronate tail, the fin folds being imperfectly continued around it, and by the greater pigmentation. The specimens appear to have reached the point of metamorphosis, the head being well round and conical, but the leptocephalous dentition persists. Elongate band-shaped, the body tapering gradually to about midway between anus and tip of caudal; depth, 11.5; head, 14.33; eye small, 2.66 in snout, 9 to base of pectoral; nostrils remote from each other by a distance equal to diameter of eye; pectorals well developed; gill slit nearly vertical; somites 66+80; tongue not free in front.

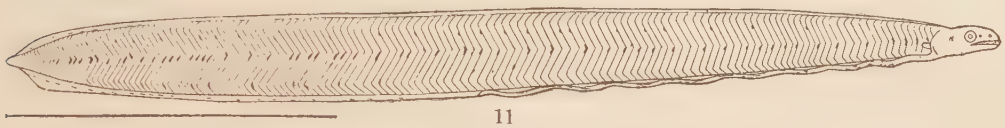
Coloration all formed by minute chromatophores, a spot near ends of jaws, a spot behind eye, another above it at nape, a series of lines of irregular length and irregularly placed at bend of the myocomma along middle of sides, a few spots near upper bend of the myocommas; a similar series of spots along lower bend of myocommas of the tail, a series of spots along dorsal, a series of spots along anal, a series of double spots above and below the alimentary canal.

Leptocephalus discus, sp. nov. Figs. 12, 12*a*, 12*b*.

Two specimens, 71 and 69 mm. long. *Albatross*, San Salvador.

This specimen differs from all others in the collection except *L. amphioxus* in possessing along the middle of the side a series of circular chromatophores placed on every second to fourth somite.

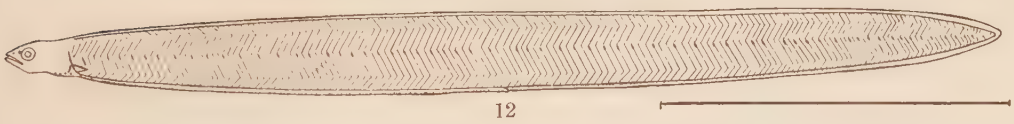
Body of nearly uniform width, tapering for a short distance in front and behind; depth about 10 in the length; head 15.5 in the length; head short and conical, the upper and lower profiles with similar slopes; pectorals well developed; dorsal beginning about the twentieth segment; caudal



11

11*a* 11*b*

Leptocephalus mucronatus.



12

12*a* 12*b*

Leptocephalus discus.

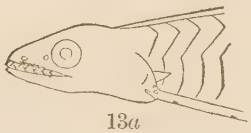
pointed, rays little developed; tail lanceolate; no pigment about head, except a series of three or four chromatophores on each side of throat; a few chromatophores above alimentary canal near its posterior end, another series on sides near base of anal; pigment between anal rays in its posterior half; a few pigment cells about base of caudal and two or three at base of some of posterior dorsal rays; middle of sides with a series of round chromatophores more numerous toward caudal; two or three chromatophores above or below this series on tip of tail.

Leptocephalus humilis Strömman. Figs. 13, 13*a*, 13*b*.

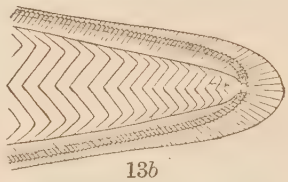
Two specimens 75 and 76 mm. long. New Providence. One 85 mm. long. *Albatross* station 2600. One 78 mm. long. *Albatross* station 2596.

This species agrees closely in most respects with Strömman's description. It differs in having a series of spots above the alimentary canal. There is a series of three or four chromatophores along the edge of the upper jaw half way between its tip and the eye; a chromatophore near the base of the pectorals; mid-dorsal line in front of the dorsal fin with a series of widely separated chromatophores; dorsal, caudal and anal with a series of chromatophores; a few chromatophores on the caudal rays; a series of spots above the spinal cord at its posterior part, these sometimes aggregated into two spots; myocommas below the median line, each with a series of from one to four chromatophores except near the head. The body is long and slender, tapering from the very slender head to behind the alimentary canal; tail pointed; segments 71 + 90; 68 + 89; 68 + 91; 69 + 93.

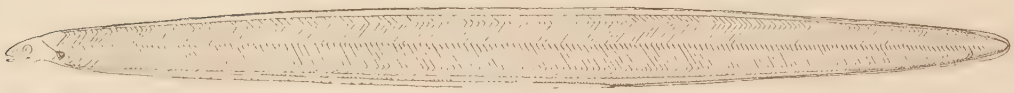
13

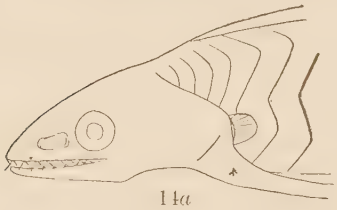


13*a*

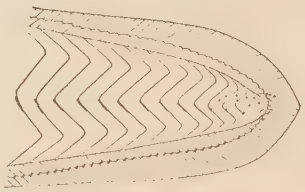


13*b*

Leptocephalus humilis.

14



14*a*



Leptocephalus gilberti. 14*b*

Leptocephalus gilberti, sp. nov. Fig. 14, 14*a*, 14*b*.

Type, one specimen 73 mm. long. *Albatross* station 2597.

This species resembles *Leptocephalus humilis*, *morrisii*, and *caudomaculatus* in shape of the head, the nostrils, the shape of tail. It differs in number of segments, distribution of spots along alimentary canal, and length of rayed dorsal. Body tapering equally to both ends from middle; depth about 12 times in length; head about half the greatest depth; snout pointed; upper and lower profiles nearly equally slanting; dorsal beginning on seventh segment behind pectoral; a chromatophore on margin of upper jaw; no other pigment about head; a chromatophore below pectoral, a series of chromatophores along upper margin of alimentary canal, congregated in places to form more or less distinct spots; a few chromatophores along ventral margin of alimentary canal; base of anal with a series of chromatophores to near caudal; a few chromatophores at base of caudal; none at base of the dorsal; a few chromatophores on tip of tail; the usual series of linear spots on myocomma beneath lateral line; segments 100 + 80.

We take pleasure in dedicating this species to Dr. Charles H. Gilbert, in recognition of his demonstration of the metamorphosis of the *Leptocephalus* of *Albula vulpes* into its adult form.

DESCRIPTION OF A NEW SPECIES OF BLENNY FROM JAPAN.

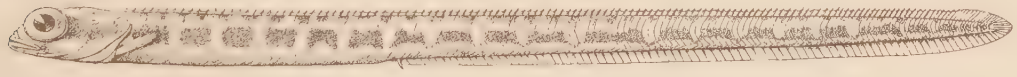
By HUGH M. SMITH.

Among the miscellaneous zoological collections made by the Fish Commission steamer *Albatross* on the coast of Japan in 1900 is a small blennioid fish belonging to a species not heretofore met with by ichthyologists and representing a new genus. The specimen was dredged at a depth of 67 fathoms, at the head of the Suruga Gulf, island of Nipon.

EULOPHIAS, new genus of Blenniidæ.

Generic diagnosis: Body very elongate; dorsal fin low, extending entire length of body and consisting of numerous rigid spines succeeded by a few simple rays; anal fin long and low, composed of one spine and numerous simple soft rays; caudal fin small but distinct, blended with the dorsal and anal; pectoral fins short and pointed; ventral fins absent; scales absent; no lateral line; gill membranes broadly united, free from the isthmus; nostrils tubular; ventral opening in advance of middle of body.

Eulophias, from εὐ, well; λοφιάς, one having a bristly back; in allusion to the very long spinous dorsal fin.



Eulophias tanneri H. M. Smith, new genus and species. (Enlarged about 2½ times.)

This genus falls within the limits of the heterogeneous family *Blenniidæ*, but must there be placed in a separate subfamily (*Eulophiasinæ*) based on the very elongate form, the shape and size of the pectoral fins, and the few soft rays in the dorsal fin, combined with the presence of a pre-anal spine and the absence of a lateral line.

This genus seems to be nearly related to no other genus. From *Cebedichthys* (represented by a single species from the Pacific coast of the United States), which it appears most closely to resemble, it differs in being much more elongated, with lower fins, more numerous dorsal soft rays, more anterior origin of the dorsal and anal fins, absence of lateral line, absence of a prominent longitudinal cephalic crest, etc. From *Neozoarces*, the type of which is from Okhotsk Sea, this genus may be distinguished by its more slender form, the presence of a caudal fin, the absence of a tentacle above the nostril, etc.

Eulophias tanneri, new species.

Body elongate, eel-like, cylindrical anteriorly, compressed posteriorly; tapering gently backward and terminating in a blunt point; greatest depth about 0.05 total body length. Head rather long, conical, not larger than body, its length 0.12 body length, terminating posteriorly in a rounded flap. Eye large, directed slightly upward, rather less than 0.33 length of head; interorbital space contracted, not wider than pupil. Snout short, rounded, 0.5 length of eye. Mouth rather large, terminal slightly oblique, jaws equal, maxillary extending to vertical of anterior edge of pupil; nostrils tubular, midway from eye to end of snout; gill membranes broadly united, not attached to isthmus. Anal orifice 0.4 distance from snout to end of body. Dorsal fin low, continuous, beginning slightly in advance of posterior edge of opercle and extending to caudal fin, gradually increasing in height from before backward; composed of 121 stiff spines and 13 simple soft rays; anal fin long and low, beginning under thirty-sixth dorsal spine and extending to caudal; consists of 1 spine and about 75 simple rays, the length of the spine being about twice that of the adjoining rays; caudal fin blended with dorsal and anal, composed of 7 simple rays; pectoral fins short, pointed, and narrow, less than half length of head. Length of specimen, 45 mm.

Colors: Underparts whitish; a series of brownish elongated blotches, about 20 in number, extends along side from head to tail; above these a series of smaller blotches of same color, about twice as numerous; a dark-brown stripe, less than width of eye, extending behind eye; a blackish blotch on cheek beneath eye, extending anteriorly and posteriorly on the branchiostegal membrane; gill membrane with dark-brown area; fins unmarked.

Type (No. 49798, U. S. National Museum) collected by *Albatross*, in about 67 fathoms, at station 3715, in Suruga Gulf, Japan, May 11, 1900.

This interesting species is named for Commander Z. L. Tanner, U. S. N., commander of the Fish Commission steamers *Albatross* and *Fish Hawk* from 1879 to 1894, the foremost exponent of the methods of modern deep-sea exploration, whose intelligent and zealous investigations have led to most valuable contributions to oceanic biology and physics.

U. S. Fish Commission, *Washington, D. C.*

LIST OF SPECIES OF FISHES KNOWN TO OCCUR IN THE GREAT LAKES OR THEIR CONNECTING WATERS.

By BARTON WARREN EVERMANN, *Ichthyologist, U. S. Fish Commission.*

In the following list are given the fishes known to occur in the Great Lakes or their connecting waters. This includes not only the streams and smaller lakes directly tributary to the Great Lakes but also the upper St. Lawrence River and the waters tributary to it. The species not known to occur elsewhere than in the hydrographic basin of the Great Lakes are indicated by a star.

The fish fauna of the Great Lakes is not particularly rich as to species, the number being scarcely greater than that known from the Wabash Basin. Of this list of 152 species and subspecies, only 27 are peculiar to the Great Lakes Basin.

1. Petromyzon marinus unicolor (De Kay). Lamprey eel.
2. *Ichthyomyzon concolor (Kirtland). Silver lamprey.
3. Lampetra wilderi (Gage). Brook lamprey.
4. Polyodon spathula (Walbaum). Paddle-fish. Only one specimen recorded from Great Lakes Basin; that from Lake Erie.
5. Acipenser rubicundus Le S. Lake sturgeon.
6. Lepisosteus osseus (L.). Long-nosed gar.
7. Lepisosteus platostomus Rafinesque. Short-nosed gar.
8. Amia calva Linnæus. Dog-fish or bowfin.
9. Ictalurus punctatus (Rafinesque). Channel cat-fish.
10. Ameiurus lacustris (Walbaum). Great Lakes cat-fish.
11. Ameiurus natalis (Le Sueur). Yellow cat-fish.
12. Ameiurus vulgaris (Thompson). Bullhead.
13. Ameiurus nebulosus (Le Sueur). Common bullhead.
14. Ameiurus melas (Rafinesque). Small black bullhead.
15. Noturus flavus Rafinesque. Stone cat.
16. Schilbeodes gyrinus (Mitchill).
17. Schilbeodes exilis (Nelson).
18. Schilbeodes miurus (Jordan).
19. *Carpiodes thompsoni Agassiz. Lake carp sucker.
20. Catostomus catostomus (Forster). Long-nosed sucker.
21. Catostomus commersonii (Lacépède). Common sucker.
22. Catostomus nigricans Le S. Black sucker.
23. Erimyzon sucetta oblongus (Mitchill). Chub sucker.
24. Minytrema melanops (Raf.). Striped sucker.
25. Moxostoma anisurum (Rafinesque). White-nosed sucker.
26. Moxostoma aureolum (Le Sueur). Common redhorse.
27. Moxostoma breviceps (Cope). Short-headed redhorse.
28. Campostoma anomalum (Raf.). Stone-roller.
29. Chrosomus erythrogaster Rafinesque. Red-bellied dace.
30. Pimephales promelas Raf. Fat-head minnow.
31. Pimephales notatus (Rafinesque). Blunt-nosed minnow.
32. Semotilus corporalis (Mitchill.) Fall-fish.
33. Semotilus atromaculatus (Mitchill). Creek chub.
34. Leuciscus elongatus (Kirtland). Red-sided minnow.
35. Leuciscus neogæus (Cope).
36. Leuciscus margarita (Cope).
37. Opsopœodus emiliæ Hay.
38. Opsopœodus megalops (Forbes).
39. Abramis crysoleucas (Mitchill). Roach.
40. Hybognathus nuchale Agassiz.
41. Chola vigilax (Baird & Girard)
42. Notropis anogenus Forbes.
43. Notropis cayuga Meek. Cayuga minnow.
44. Notropis heterodon (Cope).
45. *Notropis fretensis (Cope).
46. Notropis blennius (Girard). Straw-colored minnow.
47. *Notropis volucellus (Cope).
48. Notropis hudsonius (DeWitt Clinton). Shiner.
49. *Notropis hudsonius selene (Jordan). Lake Superior shiner.
50. Notropis whipplii (Girard). Satin-fin minnow.
51. Notropis cornutus (Mitchill). Red-fin.
52. *Notropis cornutus frontalis (Agassiz).
53. *Notropis cornutus cyaneus (Cope).
54. Notropis atherinoides Rafinesque.
55. Notropis arge (Cope).
56. Notropis rubrifrons (Cope).
57. Notropis umbratilis (Girard).
58. Notropis umbratilis cyanocephalus (Copeland).

59. Ericymba buccata (Cope).
60. Rhinichthys cataractæ (Cuvier & Valenciennes). Long-nosed dace.
61. Rhinichthys atronasus (Mitchill). Black-nosed dace.
62. Rhinichthys atronasus lunatus (Cope).
63. Hybopsis dissimilis (Kirtland).
64. Hybopsis storerianus (Kirtland).
65. Hybopsis kentuckiensis (Raf.). River chub.
66. Couesius plumbeus (Agassiz).
67. Couesius dissimilis (Girard).
68. Exoglossum maxillingua (Le Sueur). Cut-lip minnow.
69. Anguilla chrysypa Rafinesque. Common eel.
70. Hiodon alosoides (Rafinesque). Mooneye.
71. Hiodon tergisus Le Sueur. Toothed herring.
72. Dorosoma cepedianum (Le Sueur). Hickory shad. Probably introduced through canals from Mississippi basin, and possibly also through the Erie Canal.
73. Pomolobus chrysochloris Rafinesque. Probably not native, but introduced from the Mississippi basin by means of canals.
74. Pomolobus pseudoharengus (Wilson).
75. Coregonus quadrilateralis Richardson. Round white-fish.
76. Coregonus clupeiformis (Mitchill). Common white-fish.
77. Coregonus labradoricus Richardson. Labrador white-fish.
78. *Argyrosomus osmeriformis (H. M. Smith). Smelt of New York lakes.
79. Argyrosomus artedi (Le Sueur). Lake herring.
80. Argyrosomus artedi sisco Jordan. Cisco of Lake Tippecanoe. Only in certain small lakes in Wisconsin connected with Lake Michigan and certain small lakes in northern Indiana in the Wabash basin.
81. *Argyrosomus hoyi Gill. Hoy's white-fish.
82. *Argyrosomus prognathus (H. M. Smith). Long-jaw white-fish.
83. *Argyrosomus nigripinnis Gill. Blackfin white-fish.
84. *Argyrosomus tullibee (Richardson). Tullibee white-fish.
85. *Argyrosomus tullibee bisselli Bollman.
86. Cristivomer namaycush (Walbaum). Lake trout.
87. *Cristivomer namaycush siscowet (Agassiz). Siscowet.
88. Salmo salar Linnæus. Atlantic salmon.
89. Salmo salar ouananiche McCarthy. Ouananiche.
90. Salvelinus fontinalis (Mitchill). Brook trout.
91. *Thymallus tricolor Cope. Michigan grayling.
92. Umbra limi (Kirtland). Mud minnow.
93. Lucius vermiculatus (Le Sueur). Grass pike.
94. Lucius reticulatus (Le Sueur). Pickerel.
95. Lucius lucius (Linnæus). Great pike.
96. Lucius masquinongy (Mitchill). Muskallunge.
97. Fundulus diaphanus (Le Sueur). Grayback minnow.
98. Fundulus diaphanus menona (Jordan & Copeland).
99. Fundulus dispar (Agassiz).
100. Fundulus notatus (Raf.). Top minnow.
101. Eucalia inconstans (Kirtland). Brook stickleback.
102. *Eucalia inconstans cayuga Jordan.
103. *Eucalia inconstans pygmæa (Agassiz).
104. Pygosteus pungitius (Linnæus). Nine-spine stickleback.
105. Gasterosteus bispinosus (Walbaum). Common stickleback.
106. Percopsis guttatus Agassiz. Trout perch.
107. Aphredoderus sayanus (Gilliams). Pirate perch.
108. Labidesthes sicculus (Cope). Skipjack.
109. Pomoxis annularis Rafinesque. Crappie.
110. Pomoxis sparoides (Lacépède). Calico bass.
111. Ambloplites rupestris (Raf.). Rock bass.
112. Chænobryttus gulosus (Cuv. & Val.). Warmouth.
113. Apomotis cyanellus (Rafinesque). Blue-spotted sun-fish.
114. Lepomis megalotis (Rafinesque). Long-eared sun-fish.
115. Lepomis pallidus (Mitchill). Bluegill.
116. Eupomotis euryorus (McKay). Red-eared sun-fish.
117. Eupomotis gibbosus (L.). Pumpkin-seed.
118. Micropterus salmoides (Lacépède). Large-mouthed black bass.
119. Micropterus dolomieu Lacépède. Small-mouthed black bass.
120. Stizostedion vitreum (Mitchill). Wall-eyed pike.
121. Stizostedion canadense (Smith). Sauger.
122. Stizostedion canadense griseum (De Kay).
123. Perca flavescens (Mitchill). Yellow perch.
124. Percina caprodes (Rafinesque). Log perch.
125. Percina caprodes zebra (Agassiz).
126. Hadropterus aspro (Cope & Jordan). Black-sided darter.
127. Cottogaster copelandi (Jordan). Copeland's darter.
128. *Cottogaster cheneyi Evermann & Kendall. Cheney's darter.
129. Cottogaster shumardi (Girard). Darter.
130. Diplesion blennioides (Rafinesque). Green-sided darter.
131. Boleosoma nigrum (Rafinesque). Johnny darter.
132. Boleosoma nigrum olmstedi (Storer). Darter.
133. Ammocrypta pellucida (Baird). Sand darter.
134. *Etheostoma boreale (Jordan). Northern darter.
135. Etheostoma cœruleum Storer. Rainbow darter.
136. Etheostoma flabellare Raf. Fan-tailed darter.
137. Etheostoma flabellare lineolatum (Agassiz).
138. Boleichthys fusiformis (Girard).
139. Microperca punctulata Putnam. Least darter.
140. Roccus chrysops (Raf.). White lake bass.
141. Aplodinotus grunniens Rafinesque. Fresh-water drum.
142. Cottus ictalops (Rafinesque). Blob.
143. *Cottus ricei Nelson. Rice's blob.
144. *Cottus pollicaris (Jordan & Gilbert).
145. *Cottus spilotus (Cope).
146. *Uranidea franklini (Agassiz).
147. *Uranidea kumlienii Hoy.
148. Uranidea gracilis (Heckel).
149. *Uranidea formosa (Girard).
150. *Uranidea hoyi Putnam.
151. *Triglopsis thompsoni Girard. Fresh-water sculpin.
152. Lota maculosa (Le Sueur). Ling.

Contributions from the Biological Laboratory of the U. S. Fish Commission,
Woods Hole, Massachusetts.

THE ORGANIC CONSTITUENTS OF THE SCALES OF FISH.

By E. H. GREEN AND R. W. TOWER.

Mörner[1] has shown that the scales of many species of fish contain, in addition to mineral matter and collogen, a peculiar albuminoid. To this albuminoid he gave the name *ichthylepidin*. Previous observers had overlooked this substance and had considered that the organic matter in fish scales consisted wholly of collogen. The present study was undertaken to determine how widely ichthylepidin is distributed in the scales of the common American fishes.

Mörner prepared his ichthylepidin in the following way: The clean scales were digested at room temperature with a large excess of 0.5 per cent hydrochloric acid, 0.05 per cent caustic potash, and 0.01 per cent acetic acid. Each digestion extended over several days. This treatment removed soluble proteids, most of the guanin, the chrondroitin-sulphuric acid, and the inorganic matter. The residual scales were then digested with 0.1 per cent hydrochloric acid at 40° C. The residue thus freed from collogen was washed with alcohol and ether, and dried. The substance so obtained (pure ichthylepidin) was insoluble in boiling water, in cold dilute acids, and in alkalies; but it was soluble in hot solutions both of dilute acids and alkalies, and in the cold concentrated solutions of the same. It gave a strong Millon's reaction and contained much loosely combined sulphur (as shown by the blackening of the substance when boiled with an alkaline solution of lead acetate). By the two latter reactions the presence of ichthylepidin may, according to Mörner, be determined in fish scales.[2]

Mörner examined the scales of 12 species of fish, all of which showed the presence of ichthylepidin; in the ganoid scales of the American gar-pike (*Lepisosteus osseus*), however, he found no trace of it.

In the course of our work we have studied 40 species of American fish representing 25 families. In every case the scales were taken from fresh, healthy fish, and,

[1] Zeit. f. phys. Chemie, 1898, vol. 24, p. 125.

[2] Mörner, op. cit., p. 136: "Wenn man untersuchen will, ob die Schuppen einer Fischart ichthylepidinhaltig sind oder nicht, genügt es, sie nach vorgängiger Entkalkung durch Kochen, theils mit Millonschen Reagens, theils mit alkalischer Bleilösung zu prüfen; wenn dabei tief dunkelrothe Färbung, resp. Schwarzfärbung ausbleibt, ist die Gegenwart des ichthylepidins ausgeschlossen."

after being carefully freed from adhering tissue, were thoroughly scrubbed with water and washed by decantation until the water remained perfectly clear. The clean scales were then twice extracted with a large excess of 0.5 per cent hydrochloric acid (real HCl), each extraction lasting 12 hours. The scales were then washed with water until free from chlorides and finally tested for ichthylepidin as mentioned above. In some cases, where the scales could not be removed mechanically, the integument was dissolved by dilute (5 per cent) sodium hydroxide, and the scales so separated were then treated as above described. Mörner found ichthylepidin to be unchanged after several days' exposure to 5 per cent sodium hydroxide. We confirmed this fact by treating some menhaden scales with the alkali for three days, after which the presence of ichthylepidin was detected as readily as before. It was found necessary to treat the integument of all the elasmobranchs, the sun-fish (*Mola mola*), the puffer (*Spheroides maculatus*), and the remora (*Echeneis naucrates*) with 5 per cent alkali.

The scales of the following fish gave positive reactions for ichthylepidin when treated as described above:

1. Winter flounder (*Pseudopleuronectes americanus*).
2. Alewife (*Pomolobus pseudoharengus*).
3. Blue-fish (*Pomatomus saltatrix*).
4. Hickory shad (*Pomolobus mediocris*).
5. Chogset (*Tautogolabrus adspersus*).
6. Butter-fish (*Rhombus triacanthus*).
7. Tarpon (*Tarpon atlanticus*).
8. Mackerel scad (*Decapterus macarellus*).
9. Sea robin (*Prionotus carolinus*).
10. Salmon (*Salmo salar*).
11. Cod (*Gadus callarias*).
12. Haddock (*Melanogrammus æglifinus*).
13. Crevallé (*Caranx crysos*).
14. Summer flounder (*Paralichthys dentatus*).
15. Menhaden (*Brevoortia tyrannus*).
16. Tile-fish (*Lopholatilus chamæleonticeps*).
17. Squeteague (*Cynoscion regalis*).
18. Bonito (*Sarda sarda*).
19. Scup (*Stenotomus chrysops*).
20. Hake (*Phycis chuss*).
21. Sea bass (*Centropristes striatus*).
22. Silverside (*Menidia notata*).
23. Striped minnow (*Fundulus majalis*).
24. Tautog (*Tautoga onitis*).
25. Mummichog (*Fundulus heteroclitus*).
26. Remora (*Echeneis naucrates*).
27. Rudder-fish (*Palinurichthys perciformis*).
28. Common shad (*Alosa sapidissima*).
29. Sturgeon (*Acipenser sturio*).
30. Perch (*Morone americanus*).
31. Jumping mullet (*Mugil cephalus*).
32. King-fish (*Menticirrhus saxatilis*).
33. Broad minnow (*Cyprinodon variegatus*).

In all the above cases the reactions given by Millon's reagent were very marked, the red coloration being brilliant. The darkening caused by warming with the lead-alkali solution was very variable in intensity. This reaction was strong in Nos. 3, 11, 20, 21, 22, and 29 of the above list, very faint in Nos. 1, 14, 15, 27, and 28, and in the other cases ranged between the two extremes.

It is interesting to note that the ganoid scales of the sturgeon (*Acipenser sturio*) gave strong reactions with both Millon's reagent and with the lead-alkali solution, although Mörner, as above noted, found the ganoid scales of the gar-pike (*Lepisosteus osseus*) to give negative results with these reagents. In our experiments the scales were taken from the median portion of the "lateral line." They were extracted with 5 per cent HCl for 5 days, washed free from acid, and extracted with 0.05 per cent caustic potash in excess and again washed. After reextraction with 0.5 per cent HCl for 2 days, the scales were given a final washing and submitted to the tests for ichthylepidin.

In the remora (No. 26) both the scales and "sucking disk" were examined. The scales were obtained by digesting the integument with 5 per cent caustic soda for 36 hours (in the cold). The scales so removed were variable in size and shape; they were cycloidal, usually long and narrow, and were mostly pointed at one end and

rounded at the other. Intermixed were other more circular scales somewhat smaller and not pointed. They gave, after decalcification, positive reactions for ichthylepidin. The "sucking disk" of the remora, when removed and treated in the same way as the integument, also gave strong positive reactions for ichthylepidin. This fact indicates that the substance may be present not only in scales, but also in highly specialized modifications of the fins.

All the elasmobranch fishes examined gave negative results for ichthylepidin, as did also two teleosts, the sun-fish and puffer. The species investigated, with detailed analyses, are here given:

34. Dog-fish (*Mustelus canis*).
35. Sand shark (*Carcharias littoralis*).
36. Dusky shark (*Carcharhinus obscurus*).
37. Bonnet skate (*Raia erinacea*).
38. Sun-fish (*Mola mola*).
39. Puffer (*Spheroides maculatus*).

The scales of the above-named species were isolated by means of caustic potash and then decalcified and tested. In no case was there any indication of loosely combined sulphur. Millon's reagent, though it gave a slight reaction in most experiments, did not yield the characteristic rich ruby-red color given by the scales cited in the first list. The test indicates that these scales have an organic basis quite different from the others, as the following analyses will show:

Dog-fish (*Mustelus canis*).—Portions of the integument of several specimens recently killed were freed from extraneous matter, so far as possible, then washed thoroughly and placed in 5 per cent caustic soda. After three days the connective tissue had dissolved and the minute scales were washed carefully by decantation. They were now extracted with 0.5 per cent HCl for several days, the acid being frequently renewed. The washed, decalcified scales were now tested, as usual, with Millon's reagent and lead-alkali. With the former there was a faint pink coloration; with the latter there was no blackening. About a gram of the decalcified scales was now boiled in a liter of water for some time, the water being renewed as it evaporated. After a few hours the liquid became yellowish, and gelatin was detected in solution by the usual tests; after boiling for 30 hours the scales had almost completely gone into solution, a very minute quantity only remaining undissolved. The solution had the characteristics of a solution of gelatin, although it did not gelatinize, even after concentration. This was doubtless due to the long-continued boiling, which, as is well known, converts gelatin into its ungelatinizable form, B-glutin. The dog-fish scales thus seem to have only collogen as their organic basis, and to be quite free from ichthylepidin.

Sand shark (*Carcharias littoralis*).—The scales were isolated and treated as described above, except that the alkali extraction lasted five days. They behaved in every way like those of the dog-fish, and like them are free from ichthylepidin and have collogen as their organic basis.

Dusky shark (*Carcharhinus obscurus*).—The isolated scales reacted in every way like those of the dog-fish and sand shark.

Bonnet skate (*Raia erinacea*).—The skin with scales, or rather spines, attached was removed from the caudal and posterior portions of the pectoral fins and treated with 5 per cent alkali (NaOH) as before. The star-shaped spines thus isolated were washed thoroughly, extracted several days with 0.5 per cent HCl which was frequently changed. The residue was washed until the filtrate was free from chlorides. The scales gave no blackening with lead-alkali and only a faint pink color with

Millon's reagent. When boiled with water for 30 hours the scales were almost completely dissolved, and after 36 hours the undissolved residue was so small as to be negligible. The solution gave all the tests for gelatin. It gave also a strong biuret test, but not Adamkiewcz's test. Nitric acid gave no yellow color or precipitate, but subsequent addition of ammonia caused a yellow coloration. The solution responded to the alkaloidal reagents, and gave Allen and Tankard's[1] test for gelatin. No ichthylepidin is present. The organic matter of skate spines thus appears to be identical with that of the scales of the other elasmobranch fishes.

Sun-fish (*Mola mola*).—The integument was freed as far as possible from the subdermal collogenous tissue and treated with caustic soda, as before. The scales so isolated were washed thoroughly and extracted with HCl as usual. They gave a strong Millon's test, but no lead-alkali reaction. The decalcified and extracted scales were soluble in 5 per cent NaOH in 24 hours (differing from ichthylepidin, which remains unchanged for 5 days).[2] The decalcified scales were slowly but almost completely soluble in boiling water, and after 3 days only a trace remained undissolved. The solution was concentrated but did not gelatinize, although it gave all the reactions of gelatin. The scales of *Mola* are thus analogous in composition to those of the elasmobranchs above noted, and are quite different from those of the higher fish with which it is classified. It is interesting to note in this connection the studies of Milne Edwards[3] and of Parker[4] on the vascular system of this species. Milne Edwards observed that in this fish "the coronary arteries are supplied not only from the fourth gill-arch as in other teleosts, but also from the third, fifth, and sixth arches, as in elasmobranchs." Parker has confirmed this, and has shown also that the sun-fish has two coronary arteries, as is general in elasmobranchs. To quote Parker:[5]

> This confirmation of Milne Edwards's description shows that a really remarkable condition exists in the coronary arteries of the sun-fish. The presence of dorsal as well as of ventral coronaries, and the origin of the latter from more than one pair of visceral arches, are features so universally characteristic of elasmobranchs and so generally absent from teleosts that, while the sun-fish has most of the characteristic structural features of the latter, the arteries of its heart ally it unquestionably with the elasmobranchs.

This is interesting, as the composition of the scales (exoskeleton) is also analogous to that of elasmobranch scales, and the morphological structure of the scale is also very similar.[6]

Puffer (*Spheroides maculatus*).—The skin of a puffer was removed, freed from adhering tissue, and treated with 5 per cent caustic soda. After 2 days the residue of star-shaped spines was washed thoroughly and decalcified with 5 per cent HCl as above. The extracted scales gave no blackening with lead-alkali; Millon's test was distinct. The decalcified scales were treated with boiling water to determine if the basis was all collogen or if ichthylepidin was present. After boiling 30 hours there was a small residue; whether this was ichthylepidin or not we were unable to decide. The solution gave all the reactions for gelatin.

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[1] Allen, Commercial Organic Analysis (1898), vol. 4, p. 469.

[2] Mörner, op. cit., p. 131.

[3] Milne Edwards (1858), Leçons sur la physiologie et l'anatomie comparée de l'homme et des animaux. Tome 3, p. 341.

[4] Parker. Note on the blood vessels of the heart in the sun-fish. Anatomischer Anzeiger, vol. 17, No. 16–17.

[5] Parker, op. cit., p. 315.

[6] Cf. Turner, Natural History Review (1862), p. 185.

SUMMARY.

The above experiments show that in the scales of the teleosts ichthylepidin is widely distributed; in the scales of elasmobranchs and of *Mola mola* and *Spheroides maculatus* it is absent. The species cited by Mörner in his paper as having ichthylepidin in their scales are here given:

1. Abramis brama.
2. Aspius rapax.
3. Carassius vulgaris.
4. Clupea harengus.
5. Coregonus lavaretus.
6. Esox lucius.
7. Leuciscus idus.
8. Leuciscus rutilus.
9. Lucioperca sandra.
10. Perca fluviatilis.
11. Salmo salar.
12. Sebastes marinus.

In the ganoid scales of the gar-pike (*Lepisosteus osseus*) he found no ichthylepidin. Our experiments, however, show that it is detected by Mörner's reactions in the scales of the sturgeon (*Acipenser sturio*).

The scales of the sun-fish have the same general chemical composition as those of the elasmobranchs, and quite different from the scales of other higher fishes.

PROPORTION OF COLLOGEN AND ICHTHYLEPIDIN.

Mörner found the relative amounts of collogen and ichthylepidin in the organic matter of the scales of four species of fish to be, approximately, 4 parts of the former to 1 part of the latter. The determinations were made indirectly by estimation of the total sulphur. In two cases we have found the relative amounts directly by separation of the ichthylepidin and weighing it, the collogen being calculated from the difference. The process was carried out as follows: The scales were removed, cleaned, and decalcified until no more mineral matter was removed by the 0.5 per cent HCl used. The residual scales were washed free from chlorides with water, then with alcohol and ether, and dried to constant weight at 105° C. The dry organic matter so obtained was weighed, and digested with a large excess of 0.1 per cent HCl at 40 to 45° C. for 12 days. Thymol was used to prevent putrefaction. The residual ichthylepidin was filtered off, washed thoroughly with water, alcohol, and ether, and dried at 105° C. The loss in weight which the organic matter had suffered was taken as collogen.

17.7950 grams of dry organic matter from menhaden scales left a residue of 4.2255 grams (ichthylepidin) when treated as described above.

8.1550 grams of dry organic matter from shad scales left a residue of 1.9570 grams.

	Menhaden.	Shad.
	Per cent.	*Per cent.*
Ichthylepidin	23.74	24.00
Collogen	76.26	76.00

The two species thus have nearly the same relative organic composition, and the numbers found are in close agreement with Mörner's estimations. It seems that the ratio between the amounts of the two albuminoids is nearly constant in various fish whose scales contain ichthylepidin.

It may be remarked that a great difference exists (apparently) in the collogen of scales containing no ichthylepidin and those containing the latter substance. In the latter case the collogen is very loosely combined (also noticed by Mörner), a large

proportion of it being removed by boiling for 2 hours and also by digestion at 40° C. for a day with 0.1 per cent HCl. In the former case, however, the collogen is very firmly combined and is dissolved only by long-continued boiling (30 to 40 hours), and is much less affected by dilute acid digestion. Whether this is due to an essential difference in the nature of the collogen itself or to a difference in the chemical combination of it with other constituents of the scale is a subject now under investigation.

UTILIZATION OF THE COLLOGEN.

Some experiments relating to the use of the large amount of collogen present in fish scales were made tentatively. Menhaden scales were used, as these fish are now utilized in immense quantities in fertilizer works, and the removal and use of their scales, if possible, could be made at least expense. The scales can be readily removed from menhaden—more readily, indeed, than in the case of most fish.

Analyses were made to determine the amount of the collogen in the scales, both when dried at 150° C. to constant weight and when only air-dried. Also the scales from an average-sized specimen were removed and weighed to get data for determining the amount of gelatin which large quantities of moist fish would yield.

The scales from one menhaden (one-half hour after removal from the water and weighing 155 grams) were removed, washed, and thoroughly scrubbed to remove adhering tissue and then dried in the air at 20° C.

The scales, air-dried, weighed 6.9565 grams; dried to constant weight at 105° C. they weighed 5.5215 grams. The moisture in the air-dried scales then is 20.58 per cent, and the fish thus yielded 1.26 per cent scales, air-dried, or 1.004 per cent scales dried at 105° C.; that is, an average moist menhaden yields 1 per cent of its weight in anhydrous scales. One ton of fish would yield 20 pounds of dry scales.

The scales from several specimens were removed, cleaned, and dried in the air, and then to constant weight at 105° C.; 3.8180 grams of these scales were ignited and gave 1.5679 grams of ash, or 41.07 per cent ash. The organic matter by difference was 58.93 per cent. As shown above, the dry organic matter of menhaden scales contained 23.74 per cent of ichthylepidin and 76.26 per cent of collogen. Hence the following protocol:

Scales.	Air-dried.		Dried at 105° C.	
	P. ct.		*P. ct.*	
Moisture	20.58		00.00	
Ash	32.61		41.07	
Organic matter	46.80	Ichthylepidin, 11.11. Collogen, 36.69.	58.93	Ichthylepidin, 13.99. Collogen, 44.94.
Average fish yields	1.26 scales.		1.00 scales.	

Thus a ton of menhaden should yield nearly 10½ pounds of pure scale-gelatin (16 per cent moisture, as in the usual commercial article). As Mörner has shown this gelatin to be remarkably pure, containing only about 0.1 per cent ash, it should command, when properly prepared, a high commercial value.

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THE REACTIONS OF COPEPODS TO VARIOUS STIMULI AND THE BEARING OF THIS ON DAILY DEPTH-MIGRATIONS.

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INTRODUCTION.

Although the marine copepods are almost microscopic crustaceans, they are so numerous and so widely distributed that they form one of the most important constituents in the surface life of the ocean. As a food for fishes, especially the newly hatched fry, they have been justly regarded by fish-culturists as almost indispensable, and their remarkable daily migrations have been a matter of growing interest and speculation for the naturalist.

From the standpoint of oceanic food supply, the copepods form an important link between the microscopic plants and the larger animals. In the ocean, as on the land, animals feed either directly on plants or on other animals that in turn feed on plants, and, though this regression may sometimes go back several steps, all animals are ultimately dependent on vegetable life for their food. Since plants are the only forms that have the capacity of elaborating food from strictly inorganic materials, they are in reality the only independent organisms. The vegetation of the ocean, except on the very shore, differs from that of the land chiefly in being composed almost entirely of plants of microscopic size. A vegetation of this kind can not give support to large herbivorous animals such as find easy nourishment in the luxuriant plant growth of the land, but it affords an abundant supply of food for small animals like the copepods. Many copepods feed almost exclusively on the minute plants of the sea, and then fall a prey to small fishes, which in turn are eaten by larger ones. Thus the copepods form a link in the chain of food supply that reaches from the independent microscopic plants to the largest marine animals. Their place in this chain is admirably illustrated by Peck (1896, p. 353) in his account of the food of the squeteague. In the stomach of a large squeteague Peck found an adult herring in which were two young scup besides many small crustaceans. The stomach of the scup contained copepods, and the alimentary canals of these showed remains of microscopic plants (diatoms). Thus plant substance served as food for copepods, copepods for scup, scup for herring, and herring for squeteague. This sequence makes evident the importance of copepods as collectors of vegetable food which after assimilation serves as nourishment for the larger fishes.

Although many copepods have been obtained from great depths in the ocean, they are, for the most part, surface or pelagic animals. This even applies to shallow waters. Thus, in Buzzards Bay, which is probably nowhere over 20 fathoms deep, the copepods, according to Peck (1896, pp. 356–368), are about twice as abundant in the more superficial waters as in the middle depths or near the bottom. Those near the top show a remarkable daily rhythm in their movements. During the night they swarm in great numbers on the immediate surface, but from sunrise to sunset they desert the surface almost completely. This change makes itself felt in their availability as a food supply, for Peck (1894, p. 117) has observed that menhaden taken in the daytime contain fewer copepods than those caught at night. Thus the question of what determines the daily migrations of copepods is a problem not only of general interest to the naturalist, but also of practical importance to the fish-culturist.

According to Giesbrecht (1892), Weismann (1877) was the first to suggest a solution for this problem. He believed that light determined the upward and downward migration of pelagic animals and that most animals, being adapted to light of medium intensity, retreated from the surface when the light increased and moved upward when it diminished. An explanation essentially like this was accepted by Fuchs (1882). Chun (1887) opposed this view and maintained that temperature changes were probably the means of inducing daily as well as yearly migrations. The first to approach the question from an experimental standpoint were Groom and Loeb (1891), who studied the reactions to light of the free-swimming young of barnacles (*Balanus perforatus*). Their experiments showed that the animals were not constant in their reactions. When placed in a glass vessel in bright daylight they eventually deserted the side of the vessel next the window and swam away from the light, i. e., became negatively phototropic; when, however, they were placed in dim light they sooner or later reversed and swam toward the light, i. e., became positively phototropic. Since the barnacle larvæ in the aquarium, where the only changes were in the intensity of illumination, went down by day and came up by night as they did in the open sea, Groom and Loeb believed that this reaction in nature was controlled by light in essentially the same way as it could be controlled in the laboratory. Thus, while they did not deny that temperature changes might have some influence on the movements of the animals, they concluded that light, not heat, was the chief factor in controlling the daily migrations. In copepods studied by Groom and Loeb (1891, p. 176) no change in reactions to light such as that observed in the barnacle larvæ, could be discovered. Subsequently, however, Loeb (1893, p. 96) studied at Woods Hole certain copepods, most of which were probably of the species *Temora longicornis;* these could be made negatively phototropic by increasing the temperature of the water or by decreasing its density, and positively phototropic by decreasing the temperature or increasing the density. Although Loeb does not state that these factors play any important part in daily migrations, he does call attention (Loeb, 1893, p. 105) to gravity as an effective element in this respect. Animals that respond negatively to the force of gravity, i. e., are negatively geotropic, would, so far as this factor alone is concerned, continually move toward the surface. Thus one of the migratory movements might be accounted for.

From the preceding survey it is evident that the daily migration of pelagic animals is not the result of as simple a combination of circumstances as was at first supposed, and, further, that what may be effective in bringing about migration in

one species may not in another. So far as the very few copepods that have been studied are concerned, the chief factor seems to be light, though reaction to gravity has not been shown to be without influence, and heat and density of the sea water may play subordinate parts.

In attempting to ascertain the factors that determine the migration of copepods, I have carried out a series of experiments on one of the commonest summer species from the region about Woods Hole, Mass., namely, *Labidocera æstiva* Wheeler (1900, p. 178, fig. 16). This is an inconspicuous copepod of usual proportions and about 2 millimeters in length, i. e., a dozen of them placed end to end would measure very nearly an inch. The males differ from the females in three conspicuous features: First, the dorsal eye lenses in the male are larger than those in the female; secondly, the right anterior antenna of the male is partly modified to form a grasping organ, while the antennæ of the female are unmodified and symmetrical; and, thirdly, the first abdominal segment in the male is simple, and not swollen and covered with hairs, as in the female. This species was found to predominate in the tow taken during the whole of August, 1901, and served in every way as satisfactory material for experimentation.

My work was carried on in the laboratory of the United States Fish Commission at Woods Hole, and I take pleasure in expressing my indebtedness to Dr. H. M. Smith, director of the laboratory, as well as to the station corps, for many courtesies shown me.

MOVEMENTS.

At the outset I put several hundred Labidoceræ in a large, cylindrical, glass aquarium nearly filled with sea water and placed on a table near a window. In a short time the Labidoceræ had distributed themselves in a very characteristic way. One set formed a densely packed row at the top of the water on the side of the aquarium next the window; the other was formed of individuals rather uniformly scattered through the whole aquarium. The following enumerations will suffice to show the composition of these two sets: Of 25 individuals taken from the row next the light, 14 were females and 11 males; of 25 caught swimming at large, 23 were males and 2 were females. The almost complete absence of females from the latter set makes it obvious that in experimenting on this species the material should not be considered as homogeneous, but males and females should be dealt with separately.

The movements of the Labidoceræ are in part due to the animal's activities and in part to its weight. If a number of females are isolated in a small aquarium and watched, they will be seen sporting about close to the upper surface of the water. From time to time one or other will sink through the water for a distance of an inch or more, and then with a few sudden leaps will regain its former place. The sinking is apparently due entirely to the animal's weight, for it is unaccompanied, so far as can be seen, by the movement of any locomotor organs. The upward leaps are due to vigorous muscular action.

The sinking of the animal through the sea water implies that its specific gravity is greater than that of the water, and such, in fact, is the case. The specific gravity of the sea water in which this species was ordinarily taken proved on determination to be 1.025, and that of a solution of common salt, which just kept slightly etherized individuals from sinking, was found to be 1.109; the specific gravity of Labidoceræ, in reference to sea water, is, therefore, $\frac{1.109}{1.025}$ or 1.082—. In consequence of this the

animals sink in sea water, and sink at a considerable rate. The time taken by each of 10 etherized individuals to fall through 20 centimeters of sea water varied from 35.2 seconds to 47.2 seconds, and averaged 40.7 seconds. The rate of fall over different parts of the course seems to have been rather uniform, for in a second series of observations the first 10 centimeters were passed over in an average of 21.68 seconds, and the second 10 in 18.58 seconds, giving a general average for the whole 20 centimeters of 40.26 seconds. From this and the preceding observations it is fair to assume that the animals fall through the water at the average rate of about half a centimeter a second. They would thus drop a fathom in about six minutes.

The positions that the animals assume in falling through the water are different in different cases. When they are killed suddenly by adding a small amount of alcohol, formaldehyde, or corrosive sublimate to the water, and are then transferred to ordinary sea water, they descend head downward. When, however, they are placed in water containing a small amount of ether and are thus made motionless without being killed, they fall through ordinary sea water with the head uppermost. This, too, is the position assumed by the living animals when descending. The difference in the mode of descent of the dead and of the etherized animals is due to the disposition of the appendages. Strong killing reagents, such as alcohol, formaldehyde, etc., act so vigorously on the animals that they die with all their muscles contracted. Since the flexors are stronger than the extensors, the appendages, and particularly the anterior antennæ, are folded alongside the body in death and the animal moves head first through the water, probably because of the greater specific gravity of the head. In the etherized and the normal animals, on the other hand, the anterior antennæ are kept spread and the resistance that they meet in their passage through the water retards the falling of the head so that the animal descends with the head uppermost. This is of no small importance to a living Labidocera, for, being thus oriented in its fall, its first efforts at locomotion must be effective in carrying it toward the surface. Thus, irrespective of other functions that have been ascribed to the anterior antennæ, they undoubtedly serve as organs for the orientation of the body. It is not without interest to recall that the function of orientation in the higher crustaceans is also dependent, in part at least, on the anterior antennæ, although in these forms this function is connected with a special sense organ, the statocyst, whereas in the Labidoceræ the antennæ as a whole probably act in a purely mechanical way.

What has been said about the movements of female Labidoceræ applies also to the males, except that in their locomotion this sex often does what the other rarely attempts, namely, swims downward. Thus the males gain a much more general distribution than the females.

In both males and females the kinds of locomotion, except for direction, are much the same. Both sexes at times exhibit a uniform continuous movement, as though the animals were creeping rapidly through the water; at other times, and this is the more usual, they pass through the water by relatively enormous leaps, carried out at such high velocities that it is sometimes impossible to follow the animal with the eye. Although intermediate forms of locomotion occur, such as a succession of short leaps, the majority of movements belong to one or other of the two kinds just described.

The leaping movements of the copepods have been usually ascribed to the vigorous action of the anterior antennæ. Recently MacBride (1899, p. 505) has called this opinion in question and has maintained, on the grounds of observations on the slower leaping movements, that the leap is effected entirely by the simultaneous action of

the thoracic feet, and that during this operation the antennæ are held as rigid as possible at right angles to the chief axis of the body. As MacBride remarks, the extended leaps are carried out with such quickness that the parts taken by different appendages can not be directly observed, and his conclusion, therefore, is based on inference, not on direct observation. But direct observation is not the only means of ascertaining how the leap is accomplished. It is an easy matter to render copepods quiescent by putting them for a few moments in sea water containing a very little ether. Such animals recover on being placed in ordinary sea water and act in all respects normally. With a sharp-pointed knife it is possible to cut off the anterior antennæ and expanded tail ends of etherized Labidoceræ, though the other parts are too closely attached to the body to admit of easy removal. Animals from which both anterior antennæ and the tail have been removed have been kept a day or more after recovery from ether and their movements observed. They swim with great agility and seem quite as vigorous as normal specimens, but they seldom live beyond 48 hours after the operation. In their locomotion they show only one type of movement, the uniform rapid creeping. This is modified now and then by becoming somewhat uneven, but in no instance have I observed a Labidocera without anterior antennæ and tail take even a short leap.

Since in these specimens the thoracic legs are all intact and yet no leaps are made, I feel certain that these appendages are not used in the way that MacBride supposed. A Labidocera from which the anterior antennæ have been removed makes leaps that differ from the normal ones only in being somewhat shorter. If, now, the tail of such an animal is removed, the animal ceases to leap. Thus the tail is unquestionably connected with this method of locomotion. A Labidocera from which the tail has been removed can likewise leap, though in this case, also, the leaps are shorter than the normal ones. When, however, the anterior antennæ are also removed the leaping ceases. Thus the anterior antennæ, contrary to MacBride's opinion, are, in *Labidocera æstiva* at least, connected with leaping. In this species, then, the leap is performed almost exclusively by the combined action of the anterior antennæ and the tail; and the thoracic and other appendages, though they may aid it, are not capable in themselves of carrying it out. Since the anterior antennæ and the tail are not in action when the animal is creeping rapidly through the water, this motion must be ascribed to the action of other parts, probably the thoracic appendages.

From the preceding account it might be inferred that the female Labidoceræ retain their positions at the surface of the water and the males keep from accumulating on the bottom by incessant muscular activity, whereby they lift themselves against gravity; but, though this is in large part true, it is not entirely so, for it is a most usual occurrence to find both males and females attaching themselves to fixed objects, such as the sides of a glass aquarium. This they can do even when the glass is so tilted that they are well on the under side of it. If such a suspended animal be approached by a sucking tube the current of water that can thus be produced may be made to swing the animal back and forth on its support, and it can then be seen that the only parts in contact with the glass are the anterior antennæ. Not only is this so, but a careful adjustment of the strength of the current will often partially loosen the animal, so that for a while it hangs in the water with an attachment to the glass by only the tip of one anterior antenna. It is really remarkable with what success an animal thus almost completely loosened from the glass will still retain its hold. That the other appendages are not concerned in thus anchoring the animal is

made clear in two ways: First, when the animal hangs from the under side of a piece of glass the main axis of the body is nearly vertical, and thus the other appendages are not in a position to touch the glass; and secondly, when animals anchor themselves to vertical surfaces of glass they do so quite as frequently by the dorsal surface of the body as by the ventral, and, since their appendages other than the anterior antennæ are on the ventral side, it follows that when they rest with the dorsal surface to the glass the only appendages that can touch the glass are the anterior antennæ. How the antennæ adhere to the glass is not certainly known, but it is quite probable that the attachment is accomplished by means of the numerous hairs that cover these organs and that are especially abundant at the tip. (Wheeler, 1900, p. 179, fig. 16*c*.)

Not only can Labidoceræ anchor themselves by their antennæ to fixed objects in the water, but they can likewise hold to the surface of the water. A jar of water containing many Labidoceræ can be so placed that the animals may be seen hanging from the surface of the water exactly as they would hang from the under surface of a piece of glass. To the surface of the water as to the glass the animals are attached by their anterior antennæ. Slight waves are sufficient to dislodge them, but in quiet water great numbers hang in this way for considerable periods.

The mechanism of attachment in this as in the former case has not been definitely ascertained, though it is very likely, as Scourfield (1900, p. 307) has suggested, that the hairs of the anterior antennæ pierce the surface film of the water and produce capillary depressions by which the weight of the body may be supported.

Thus, Labidoceræ, whose weight ordinarily causes them to sink in sea water, overcome this tendency by gliding movements involving the action of their more centrally placed appendages, by leaps accomplished through the combined action of tail and anterior antennæ, and by attaching themselves through the anterior antennæ to fixed objects in the water or to the surface film. In these operations the anterior antennæ perform at least three functions: They orient the animal mechanically as it falls through the water, they are organs of positive locomotion in connection with the leaping habit, and, finally, they are organs of attachment while the animal rests.

REACTIONS TO GRAVITY (GEOTROPISM).

As already pointed out, most female and many male Labidoceræ frequent the top of the water in any large aquarium much as they do the top of the sea, and, as we have seen, they are continually falling from this situation because of the influence of gravity and as continually exerting themselves to regain it. Do the Labidoceræ move toward the surface because it is nearer the source of light, i. e., are they positively phototropic, or do they move in that direction because it is away from the earth's center of gravity, i. e., are they negatively geotropic?

To test this question a large glass tube about 8 centimeters in diameter and some 60 long, with one end open and the other closed, was set up vertically and nearly filled with sea water. On the side of the tube, and beginning at the bottom, five intervals of 10 centimeters each were laid off and marked, and the water in the tube was made to stand at the 50-centimeter mark. The apparatus was so arranged that the tube could be inclosed in a light-proof jacket without disturbing the contents by jarring, etc.

The first experiment consisted in putting five female Labidoceræ in the tube and recording their distribution under the influence of diffuse daylight. The sections in

the tube were numbered from the bottom up, I to V, and the records were taken at the ends of five-minute intervals till ten records were obtained. The results are indicated in Table 1, where it appears that in eight records out of ten all five animals were in the uppermost section, and that in two records one animal in each case had descended to the fourth section:

TABLE 1.

Five-minute intervals.		1	2	3	4	5	6	7	8	9	10	Totals.
Sections of the tube.	V	5	5	4	5	5	4	5	5	5	5	48
	IV	0	0	1	0	0	1	0	0	0	0	2
	III	0	0	0	0	0	0	0	0	0	0	0
	II	0	0	0	0	0	0	0	0	0	0	0
	I	0	0	0	0	0	0	0	0	0	0	0

To ascertain how much influence light had in bringing about this condition, the tube with its contents was now placed in perfect darkness and exposed for a moment to light every five minutes to record the distribution of the Labidoceræ. Table 2 shows the results of this experiment.

TABLE 2.

Five-minute intervals.		1	2	3	4	5	6	7	8	9	10	Totals.
Sections of the tube.	V	5	5	5	4	5	3	5	4	5	5	46
	IV	0	0	0	1	0	2	0	1	0	0	4
	III	0	0	0	0	0	0	0	0	0	0	0
	II	0	0	0	0	0	0	0	0	0	0	0
	I	0	0	0	0	0	0	0	0	0	0	0

Here in seven records out of ten all five animals were in the uppermost section; in the remaining three records four animals were in the fourth section. Thus the record in Table 2, though not quite so nearly uniform as in Table 1, differs so little from the latter that the conclusion that female Labidoceræ stay at the top of the water because of some other stimulus than light is entirely justifiable.

Although, next to light, gravity is the most probable factor in determining the distribution of female Labidoceræ, it might be assumed from anything that has thus far been shown that these animals seek the surface because of the greater abundance of oxygen there. To test this assumption a large glass tube, such as that described on page 108, was filled with sea water and inverted in an aquarium in such a way that no air entered it. Five female Labidoceræ were introduced at the lower open end; they swam rapidly to the upper end, where they were, of course, at the top of the water, but without being in contact with the air. Here they remained till their deaths stopped the experiment. The first one died 68 hours after introduction; the last one 85 hours. As the animals remained persistently at the upper closed end of the tube, it is evident that the atmosphere is not a factor in determining this feature of their distribution. If, then, neither light nor atmosphere is essential in keeping female Labidoceræ at the surface of the water, the only other probable factor is gravity, and, as these animals persistently work against gravity in keeping near the surface, their geotropism is negative.

With the male Labidoceræ the case is quite different. First of all, they can be divided into two classes—those that are found at the surface with the females and those that are scattered through the water. Individuals from both these classes were subjected to experiments such as have been already described for the females. Table 3 shows the distribution at five-minute intervals of five males taken from the class of scattered individuals and open to the action of both light and gravity, as in the first experiment with the females (Table 1).

TABLE 3.

Five-minute intervals.		1	2	3	4	5	6	7	8	9	10	Totals.
Sections of the tube.	V	2	1	1	0	1	1	1	1	0	0	8
	IV	1	1	2	2	0	1	0	1	1	1	10
	III	0	1	0	2	2	1	2	0	1	1	10
	II	2	2	1	0	1	0	0	2	2	1	11
	I	0	0	1	1	1	2	2	1	1	2	11

The distribution as shown in this table indicates almost complete indifference, as might have been expected from the previous distribution of these animals in the water.

Table 4 shows the results from the same five males when the tube was placed in the dark, as in the second experiment with the females (Table 2).

TABLE 4.

Five-minute intervals.		1	2	3	4	5	6	7	8	9	10	Totals.
Sections of the tube.	V	0	1	1	2	1	1	1	1	2	1	11
	IV	2	1	1	0	2	1	1	2	0	1	11
	III	1	2	1	1	0	1	2	0	1	0	9
	II	1	0	1	2	1	0	1	1	1	1	9
	I	1	1	1	0	1	2	0	1	1	2	10

The results shown in this table are so nearly like those in Table 3 that it is safe to assume that light plays no important part in the distribution of this class of males.

The second class of males, those found at the surface with the females, might naturally be expected to show the same reactions to light, gravity, etc., that the females do. This, however, is far from the case. Table 5 gives the distribution of five males taken from among the females at the top of the water, and placed by themselves in a glass exposed to diffuse daylight, as in the first experiment with the females.

TABLE 5.

Five-minute intervals.		1	2	3	4	5	6	7	8	9	10	Totals.
Sections of the tube.	V	1	1	0	1	0	1	1	1	2	1	9
	IV	2	1	1	1	1	0	1	1	1	2	11
	III	0	0	2	1	2	2	1	0	1	0	9
	II	1	2	1	2	2	2	0	0	1	0	11
	I	1	1	1	0	0	0	2	3	0	2	10

It is evident from this table that the separation of the males from the females totally changes the plan of distribution of the males. They become scattered more or less uniformly, as in the case of the first class of males. They likewise are undisturbed in their new distribution by the absence of light, as is shown in Table 6, in which the distribution of the same five males used for Table 5 is recorded, but with the difference that the tube was kept in total darkness except for the brief periods of observation.

TABLE 6.

Five-minute intervals.		1	2	3	4	5	6	7	8	9	10	Totals.
Sections of the tube.	V	0	1	1	2	1	1	0	1	1	1	9
	IV	1	0	1	1	1	1	2	1	1	2	11
	III	1	2	1	0	1	2	1	0	2	0	10
	II	2	0	1	1	1	0	1	2	0	1	9
	I	1	2	1	1	1	1	1	1	1	1	11

The essential agreement of Table 5 with Table 3 and of Table 6 with Table 4 shows that all males react or fail to react to light, gravity, etc., in much the same way, and that it is the responses to the females rather than to other factors that divide the males into two classes. So far as their reactions to light, gravity, etc., are concerned, all males form in reality only a single class.

It must be evident from the preceding experiments that light is a very subordinate factor in determining the distribution of the males, if, in truth, it is to be reckoned with at all, and it might further be supposed, since the males when left to themselves do not collect either at the top or at the bottom of the aquarium, that they therefore are also uninfluenced by gravity, i. e., that they are not geotropic. This conclusion, however, would be erroneous, in my opinion, for the bodies of the males are quite as heavy as those of the females, and are continually falling toward the bottom. If the males did not react against this, i. e., were slightly negatively geotropic, they would eventually all reach the bottom, a form of distribution which we know does not occur. I therefore believe that the males also are negatively geotropic, but only sufficiently so to keep them from collecting at the bottom and not enough to cause them to collect at the top, as the females do.

Two conclusions may now be regarded as well established: first, that the female Labidoceræ are strongly negatively geotropic, and, secondly, that the males are slightly so. The first of these makes clear why under natural conditions the females come to the surface of the sea and stay there; neither helps us to understand why the males congregate with the females or why the latter at stated intervals desert the surface of the sea.

Loeb (1893) long ago pointed out that by appropriate stimulation the sense of an animal's response might be inverted; thus an organism positively phototropic under ordinary conditions might by a slight change in its environment become negatively phototropic. It is therefore necessary, in attempting a further insight into the daily migrations of the copepods, to ascertain whether there are not means at hand for converting the negative geotropism of the females into a positive geotropism, thus establishing a sequence of events that might offer an explanation of daily migration. Heretofore some of the most successful means in accomplishing such inversions have been mechanical stimulation, as agitation of the water in which the animals are, and changes in the density and in the temperature of the sea water.

Both the male and the female Labidoceræ, after the rough handling incident on being squirted several times from a pipette into a vessel of sea water, still showed unchanged their characteristic geotropic responses; and even after they had been violently shaken in a test tube partly filled with sea water no alteration in their geotropism was observed. Mechanical stimulation, therefore, seemed insufficient to change their reactions to gravity. This accords with what was observed on the surface of the sea, for at night Labidoceræ were often as abundantly obtained when the sea was rough as when it was smooth.

Changes in density were next tried. Sea water of a specific gravity 1.025 was filtered, concentrated by boiling, cooled, and aerated, and then diluted with distilled water till the requisite densities were obtained. Females introduced into waters of specific gravities 1.050 and 1.035 retained their negative geotropism and showed no differences from normal animals except that they moved more frequently by leaps. Males when placed in similar concentrations frequented the upper portion of the vessel more generally, i. e., had their negative geotropism somewhat increased, and leaped more frequently. Concentrated sea water then induced leaping movements in both sexes, increased slightly the negative geotropism of the males, without, however, making any noticeable change in the geotropism of the females.

In sea water of less density than the normal, the reactions of the males and the females, unless otherwise stated, were similar, and the following records apply to both sexes. In sea water diluted from 1.025 to 1.020 the animals darted about when first introduced and then gradually became distributed as was usual, the females near the top and the males scattered. In water of the specific gravity 1.015 the animals introduced darted about vigorously, after which some went to the bottom, 50 centimeters distant, and some remained above. In water of a specific gravity 1.010 all animals exhibited darting movements and went to the bottom in irregular spirals. They were left in the mixture, and all died in the interval between a half hour and an hour after introduction. In water of a specific gravity 1.005 all fell rapidly, each making one or two leaps and reaching the bottom apparently dead. In pure water the animals made one or two leaps, and were dead before they reached the bottom. The effect of diluting the sea water did not seem in any case to change geotropic responses. Slight dilution stimulated the Labidoceræ to leaping, and greater dilutions, after stimulating them to a few leaps, rendered their movements incoordinate, so that they fell to the bottom without showing responses which at any time could have been interpreted as a change in the sense of their geotropism.

When ordinary sea water was covered by an inch or so of sea water diluted to a specific gravity 1.015 and Labidoceræ were liberated at the surface, they almost always sank with a few violent leaps till they entered the ordinary sea water, whereupon they became normally distributed, in that most of the males dispersed and the females congregated near the upper surface, not of the water as a whole, but of the normal sea water.

This experiment indicates that under natural conditions even excessive rain is not likely to change essentially the distribution of Labidoceræ, for they would at most be driven only a few inches from the surface. Dropping fresh water into a tube of sea water containing female Labidoceræ, so that in the course of about an hour the level of the tube rose a centimeter, could not be said to have driven the animals from the surface, though they occupied a somewhat deeper position at the

end of the experiment than at the beginning. The exposure of a similar tube to an actual shower of rain on a very dull day was followed by no observable change in the distribution of the animals. Rain, therefore, with the slight accompanying change in the density of the surface waters, plays no part worthy of consideration in the distribution of Labidoceræ.

Temperature changes were next tried. In testing the effects of these changes, animals were used that had been kept several days in a large glass aquarium, whose temperature was uniformly 23° C. Five male Labidoceræ were transferred from the general aquarium to the large glass tube described on page 108, now filled with sea water at 23° C. to the 50-centimeter mark. The animals were soon scattered through the water, as characteristic of males. They were now carefully taken out, and the water changed for some at 15° C. On reintroducing the males, they again gradually scattered through the water. The same was true for water at 10° C., as well as for that at 30° and 35°. These temperature changes, therefore, did not alter the distribution of male Labidoceræ.

Five females were then subjected to a series of corresponding experiments. At 23° C. the females remained near the top, and the same was true at 15° and 10° C. At 30° C. and at 35° C. all the animals swam rapidly downward to the bottom. To ascertain whether this reaction was in any way connected with a possible change of the animals in reference to light, the experiments were repeated in the dark. Five females were introduced into the tube containing water at 30° C. and the tube placed in a light-proof chamber. After 10 minutes the tube was inspected, and all five animals were found at its bottom. There thus seems to be no question but that an increase of temperature over the normal converts the geotropism of female Labidoceræ from negative to positive.

Something of the nature of this change may be inferred from the following experiments. Five negatively geotropic females were introduced into a large vessel filled with sea water at 30° C. They immediately became positively geotropic and swam to the bottom. After having remained there some minutes they were transferred by a pipette to the bottom of a second vessel filled with sea water at 24° C. They immediately became negatively geotropic and swam to the top. The change from one condition to the other, as these experiments showed, takes place almost instantly, and the condition lasts only as long as the appropriate stimulus is present. This may be illustrated by another experiment. The lower half of a large glass tube was filled with sea water at 24° C., the upper half with sea water at 30° C. The warmer water was poured into the tube so as to mingle as little as possible with the cooler water. A female Labidocera was now introduced at the top to ascertain whether she would swim to a point deeper than the separation between the waters of different temperatures. She swam rapidly downward, but stopped almost exactly at the plane of separation for the two temperatures. A second tube was prepared containing sea water at 21° C. in the lowest third, at 23° C. in the middle third, and at 35° C. in the uppermost third. In this tube a thermometer was hung by a thread and a female Labidocera introduced at the top. She swam down almost at once to a point near the middle, which, the thermometer having been adjusted, was found to have a temperature of 23° C.; she then rose somewhat, and five minutes after introduction was in water of 26° C. Ten minutes later she had risen somewhat farther, but was still in water registering 26° C. After half an hour, when the water in the top of the

tube was at 26.5° C., she was still some inches from that level and in water at 26° C. It would therefore seem that 26° C. is the temperature limit above which this female Labidocera became positively geotropic.

That there should be no question about the difference between the males and the females in their capacity to be transformed geotropically, the following experiment was tried. Ten animals taken at random from the top of the general aquarium were suddenly introduced with as little water as possible into a tube filled with sea water at 30° C. They quickly separated into two sets, one going to the bottom, the other remaining near the top. The six that remained near the top were picked out and all proved males; the four that swam to the bottom were then recovered and found to be females. These observations show that the temperature of the water has no obvious effect on the slight geotropism of the males. The geotropism of the female is negative in cold water and positive in warm, and for normal animals the critical temperature seems to be about 26° C.

It thus appears that of the three means suggested whereby the sense of the geotropism of Labidoceræ might be changed, only one, namely, temperature, has proved really effective. The critical point in the temperature change is, however, so high, compared with any temperature range the animal is likely to meet with naturally, that the assumption that the daily migrations of the females depend on geotropism changed from negative to positive and back again by temperature differences is wholly unwarranted. So far as one can see, the only part played by geotropism in the daily migrations affects the females; they rise to the surface and stay there because of their strong negative geotropism.

REACTIONS TO LIGHT (PHOTOTROPISM).

Light, like gravity, influences bodies of water, as a rule, from one side only, and, since it increases and decreases during the day, it has naturally been regarded as a potent factor in determining the daily migrations of pelagic animals. That it plays a part in the distribution of copepods can be seen from the fact that in an aquarium standing near a window many Labidoceræ congregate near the surface of the water on the side next the window; i. e., they are positively phototropic.

If a considerable number of male Labidoceræ are placed in a large glass jar filled with sea water and illuminated from one side, they will soon be found scattered through the water. A close inspection, however, will show that rather more are in the half of the jar away from the light than in the half toward it. To determine with greater accuracy what this difference amounted to, a nearly cubical glass jar filled with sea water was so arranged that a temporary glass partition could be slipped into it vertically, thus dividing its contents into a front and a back half. One meter in front of the jar was placed an incandescent electric lamp of about 14-candle power. The light from this fell perpendicularly on the front face of the jar and the partition was so placed that of the two chambers formed by it one was toward the lamp, the other away from the lamp. The partition having been withdrawn, ten male Labidoceræ were liberated in the middle of the jar and after ten minutes exposure to the light the partition was inserted and the numbers in the chamber toward the light and in that away from it were counted. The experiment was then repeated, the Labidoceræ being each time liberated at the center of the jar and allowed ten minutes in which to become distributed. Table 7 gives the result of ten such trials.

TABLE 7.

Number of experiment.	1	2	3	4	5	6	7	8	9	10	Totals.
Number of animals in chamber toward light	5	4	4	6	4	3	6	4	5	5	46
Number of animals in chamber away from light	5	6	6	4	6	7	4	6	5	5	54

These results support in the main the opinion formed from the more cursory inspection of the jar. As a whole the assemblage of males shows slightly negative phototropism. These experiments do not, however, preclude the possibility that some individuals are slightly positive and some indifferent; they merely show that more individuals are slightly negative than otherwise. When a single male is put in a large open glass jar, the animal can usually be driven about from one side to the other by holding an electric light (14-candle power) close to the jar. The reaction is never very quickly performed and sometimes fails entirely, but usually after a few minutes the animal swims from the illuminated side to the opposite one and stays there persistently. Although it is generally not difficult to drive a male Labidocera by light back and forth horizontally through a jar, I found it almost impossible to drive them up or down through a thickness of water equal to that through which they would move horizontally. Sometimes this seemed to succeed, but generally not, and I was finally forced to conclude that, slight as the geotropism of the males was, it was more effective than their phototropism.

Female Labidoceræ collect on the light side of a jar with great precision. Since they are also negatively geotropic they keep close to the top of the water. When ten females were exposed to light in the square glass jar with the partition as described for the males (p. 114), all were found in all ten trials in the chamber next the light. Their positive phototropism is thus clearly indicated.

Further evidence of this peculiarity was observed in several ways. The large upright glass tube marked off at 10-centimeter intervals (p. 108) was filled with sea water to the 50-centimeter level and five females were placed in it. The whole was exposed to diffuse daylight in a room, and the Labidoceræ soon congregated at the top of the water on the side of the glass nearest the window. An opaque cover was now slipped over the top of the tube and down to the 40-centimeter mark. In a few moments all five animals had dropped to this level, and remained here as long as the cover was kept in this position. This result was essentially the same as that observed by Loeb (1893, p. 160) for *Temora longicornis*, except that in Loeb's experiments the copepods were checked in their upward movements by the opaque cover instead of being driven downward by it. In either case it shows that the animal's positive response to light is stronger than its negative response to gravity. By lowering such an opaque hood over the tube the Labidoceræ were driven to the bottom of the tube, where they remained as though imprisoned. They retained this position as long as a small amount of light was allowed to enter at the bottom, but the moment this was cut off they presumably began to rise, for on removing the hood ten minutes later they were all found at the top of the water. Thus their negative geotropism is at once made effective by complete darkness.

The rates at which some of these reactions were carried out are not without interest. In one set of experiments the females were made to descend 15 centimeters from the surface by means of the opaque hood. From the time the hood was put on, which presumably marked the beginning of the descent, till the arrival of the animals below, was exactly 30 seconds. This indicated a descent at the rate of half a centimeter per second, which has already been shown to be the rate of passive falling. So far as one could judge from the first sight of the animals as they emerged below the level of the hood, they did descend by falling and not by any form of positive locomotion. It would, therefore, seem that diffuse daylight from below acts on female Labidoceræ rather as an inhibiter of their negative geotropic reactions than as a positive phototropic influence. On the removal of the hood the females returned to their original position, but required 1½ minutes to perform this migration. They thus descended three times as rapidly as they ascended—i. e., if they can descend a fathom in about 6 minutes they could probably not make that ascent in less than 18 minutes.

In another experiment five female Labidoceræ were put in a glass tube, of large caliber and about 50 centimeters long, and hung vertically in a dark chamber. When an incandescent electric lamp (14-candle power) was brought near the side of the tube, the five animals crowded close to it. When the lamp was held at the top they all ascended to the top, and they could easily be induced to descend through 50 centimeters of water by holding the lamp under the bottom of the tube. Their descent was accomplished chiefly by passive falling, with the anterior end uppermost, though now and then they swam downward, an unusual action for a female. In this experiment, as in former ones, the responses of the females to gravity were always subordinate to those to light—i. e., geotropism was less pronounced than phototropism.

A curious relation between these two sets of reactions was seen in the following experiment. The large tube, graduated to 10-centimeter intervals, was filled with sea water to the 50-centimeter mark; into it were put five females and the apparatus was covered with an opaque hood from the top to within 5 centimeters of the bottom. In this lowest section of 5 centimeters all the females congregated. The hood was now taken off in sections, beginning at the top. First, the top with 5 centimeters of the side covering was removed, leaving the tube covered for a distance of 40 centimeters, beginning at 5 centimeters from the bottom. On thus illuminating the interior of the tube from above, it might have been expected that the five females would have risen through the dark section to the now light top; they, however, remained at the bottom. The uppermost 10 centimeters of the side covering were next removed, leaving 30 centimeters still covered, but without effect on the animals. The next lower 10 centimeters were now taken off, leaving 20 centimeters covered, whereupon four of the Labidoceræ immediately swam upward through the dark section to the light at the top. On removing the next 10 centimeters of the side covering the fifth animal ascended. Thus it appears that a dark region between a light top and light bottom may prevent female Labidoceræ from ascending, an operation, however, that they may perform before all the dark section has disappeared.

The experiments on light thus far described make it clear that the phototropism of the male Labidoceræ is at most slightly negative, that of the females strongly positive. So far as these facts are concerned they seem to have little bearing on daily migrations, for the slight negative phototropism of the males is not sufficient to over-

come their negative geotropism and the positive phototropism of the females might be expected to bring them to the surface of the sea in the day instead of in the night, as is their habit.

The positive phototropism of the females is, however, so strong that the question arises here, as it did in connection with geotropism, Are there not perhaps natural means of inverting this? Certainly the conditions in the laboratory did not reproduce those in the outer sea water, for in a large jar kept on the laboratory table the female Labidoceræ kept persistently near the top of the water day and night, although in another large jar floated in the outer basin of the Fish Commission dock, and thus freely exposed to the elements, the females made regular migrations, being close to the surface in the night and at the bottom in the day.

Experiments were now undertaken to ascertain whether the sense of the phototropism of the females or possibly even of the males could be changed. Loeb (1893, p. 96) found that for the copepod *Temora longicornis* an increase of temperature changed positively phototropic individuals into negatively phototropic ones and intensified the negativity of negative specimens, and that a decrease of temperature changed negative into positive individuals and increased the positivity of positive ones. Holmes (1901) found that in certain amphipods an increase of temperature certainly hastened and perhaps induced the positive condition. Yerkes (1900, p. 417) was unable to change the sense of the light reactions of *Daphnia* and of *Cypris* by temperature differences. All efforts to change the phototropism of Labidoceræ by changing the temperature of the sea water were without avail. Both males and females taken from water at 23° C. and placed in waters at 10°, 15°, 30°, and 35° C. remained, so far as their phototropism was concerned, unchanged.

Density differences were next tried. Loeb (1893, p. 97) had shown that in *Temora* dilution of the sea water made positive individuals negative, concentration the reverse, but in Labidocera, animals taken from sea water of a specific gravity 1.025 and placed in waters of 1.050, 1.035, 1.020, 1.015, 1.010, 1.005, and 1.000 specific gravity showed no phototropic changes.

Loeb (1893, p. 96) noticed that when *Temora* was first caught, it was often positively phototropic, though under ordinary circumstances it was negatively so. Shaking made the animals temporarily positive, and probably explains the peculiarity just mentioned. Towle (1900), by a most painstaking series of experiments, showed that *Cypridopsis* was usually negatively phototropic, but that contact with a pipette and other slight mechanical stimulations were sufficient to make it temporarily positive. Conditions parallel with those in *Temora* and in *Cypridopsis* were often found in Labidocera. Females are ordinarily positively phototropic, but after having been several times vigorously ejected from a pipette into sea water, the majority of them become temporarily negative.

The following laboratory record will show clearly the nature of this change.

Aug. 20 (1901), 7.35 p. m. Five positively phototropic females were ejected, each one three times, from a pipette into sea water. Two remained positive and three became negative, swimming to the side of the glass vessel away from the light.

7.45 p. m. One of the three negative individuals became positive and swam with some irregularity to the two positive individuals on the light side of the vessel.

7.58 p. m. The second negative individual became positive.

9.20 p. m. The third and last negative one became positive.

Since females can be rendered negatively phototropic for a period of almost two hours by handling them with a pipette, it might be inferred that this is due to simple mechanical stimulation. That such is not exactly the truth is seen in the fact that female Labidoceræ agitated in the water do not become negative even when this process is several times vigorously repeated, although these same animals easily change on being handled with a pipette. Apparently, then, it is a very special form of mechanical stimulus that is necessary to call forth this reversal.

Pipette experiments with five males, which in the beginning were almost indifferent or only slightly negative to light, resulted in making all distinctly negative, a condition which lasted at most an hour and a quarter.

Although certain forms of tactual stimulation are a means of making both males and females move away from a source of light, even, as I found by experiments, downward through the water, they can not for a moment be regarded as the efficient cause in the downward movements of the Labidoceræ each morning, for the animals are quite as much open to agitation at other times of day as in the early morning.

Notwithstanding that this change has probably no connection with the daily migrations, it may have a very important connection with the pairing habits of the animals. As is well known, the right antenna of the male is modified to form a grasping organ, and by means of this the male seizes the female in pairing and holds her till he has deposited a spermatophore on the posterior part of her body. I have observed pairing among Labidoceræ a number of times, and it has always taken place between individuals at the top of the water. After the male has seized the female, the pair plunge about in a most violent manner, and it has occurred to me that the mechanical stimulation thus produced might be sufficient to render both negatively phototropic, so that after release they would move downward to the water where fewer individuals were. This operation, if it really takes place, would have the effect at least of removing from the pairing individuals any two that had recently been in union. After this idea occurred to me, I observed only one pair in copulation. These were removed from the general aquarium to determine whether after separation their light reactions had changed. After separation, however, both male and female exhibited their usual phototropic responses, no change having taken place, but on examining the female no spermatophore was found on her, and possibly the operation was incomplete in respect to light as it was in sexual matters.

Attempts were next made to ascertain whether the continuance of light action or a difference in its intensity could induce changes in the Labidoceræ. Groom and Loeb (1891) observed that the free-swimming larvæ of a barnacle were positively phototropic in the morning, but that before noon and without other changes than continued light action they became negative. These in the course of the night all became again positive. Thus the continued action of bright light gradually made the larvæ negative, of dim light positive.

To ascertain the effect of this form of continuous light action on Labidoceræ, I put five males in one large jar of sea water and an equal number of females in another. These were exposed to diffuse daylight in the laboratory, as in Groom and Loeb's experiment, the jars having been set up August 12. On August 20 one male died, the other four succumbed between August 24 and 26. One female died August 24,

and the experiment was discontinued August 26. During all this period the males and females retained their characteristic distribution, and nothing whatever suggestive of daily migrations was observed. Thus the changes noticed by Groom and Loeb in barnacle larvæ failed entirely to appear in Labidoceræ.

Lights of different intensities were next tried. When an electric incandescent lamp of about 14-candle power was held at 10 centimeters from a glass vessel containing female Labidoceræ, the animals came to the side next the light; they likewise went to the top or to the bottom of the vessel, depending upon whether the light was held above or below it. These same reactions obtained when a concentrated solution of alum was used as a means of excluding heat rays. The reactions are therefore due to light.

When, in place of a 14-candle lamp, one of about 100-candle power was used, the results were very different. The Labidoceræ, on first being approached by the intense light, made one or two leaps and then swam directly away from the light. If the lamp was placed above them they moved to the bottom of the aquarium (about 30 centimeters); if, now, the light was quickly brought under the vessel, the animals rose. This latter response was doubtless coupled with their negative geotropism. Thus it is obvious that female Labidoceræ are positively phototropic to light of low intensity, and negatively so to light of high intensity.*

The phototropism of the males was not noticeably different in the intense light from what it was in the dim light. Under both conditions they were, as a rule, slightly negative.

These observations make clear why the female Labidoceræ are not at the surface of the sea in the daytime. They are negatively phototropic to its bright light, and therefore pass downward to the deeper water, where, from absorption by the upper layers, the light has decreased in intensity.

To demonstrate the validity of this conclusion, a jar of female Labidoceræ was covered with a glass dish containing 4 inches of a saturated alum solution to absorb heat rays and then exposed to direct sunlight about noon. Immediately on being put in the sunlight the animals retreated from the source of light and went to the bottom of the jar. In this respect they were like *Simocephalus sima* as observed by Rádl (1901, p. 83). On excluding sunlight from the jar the Labidoceræ again rose, and they could be thus driven up and down at will.

The migrations thus produced undoubtedly imitated in miniature the natural daily migrations of female Labidoceræ in the sea. These animals migrate into deeper waters on the coming of daylight because of their negative phototropism to strong light. They return to the surface on the approach of night because of their positive phototropism for weak light and their negative geotropism, a combination which Loeb (1890, p. 42) has already shown in the larvæ of the brown-tail moth. In this way the migrations of the females are accomplished, and the only reason why these animals do not carry out similar daily movements in the laboratory is because of the absence of one factor, intense light.

*Conditions of this kind, so far as reactions to light intensities are concerned, were apparently first noticed by Famintzin (1867) in the protozoans *Chlamidomonas* and *Euglena*, and have since been observed in the following animals: *Hydra* (Wilson, 1891), *Polygordius larvæ* (Loeb, 1893), *Daphnia* (Lubbock, 1884), and *Limax* (Frandsen, 1901).

Although this explanation makes clear the movements of the females, it in no wise applies to the males, for, as we have seen, they are almost indifferent to the effects of light and gravity. The occasion of their migrations must be sought for in other factors.

REACTIONS TO SUBSTANCES IN THE WATER (CHEMOTROPISM).

The Labidoceræ that collect at the surface of the water on the light side of an aquarium have already been shown to be some males and some females. A hundred or more of these were placed in an aquarium filled with sea water and in a short time the majority of the newcomers were found at the top of the water near the light; others, however, were scattered throughout the whole body of water. These scattered individuals were then picked out, and, as might have been expected, were found to be almost exclusively males. An hour or so after this the aquarium was again examined and was apparently as full of scattered males as before. These, like their predecessors, were removed. After a time, however, they seemed to reappear, although in diminishing numbers. The process of picking out was continued until few or no scattered individuals could be found. An examination of the assemblage at the top now showed it to be made up almost exclusively of females, the males having escaped for the most part to the lower water, where they were picked out. Under ordinary conditions, then, males are continually escaping from the assemblage of males and females at the surface and swimming off to become scattered individuals in deeper water.

The males not only are continually leaving such an assemblage; they are also continually entering it. At the bottom of a glass aquarium containing only female Labidoceræ ten males were liberated. They swam about as scattered individuals for some time, but after half an hour only six could be seen; four, as a close inspection showed, had joined the assemblage of females at the top. The females must, therefore, be admitted to have some power of attracting the males.

It occurred to me that the possible phosphorescence of the female might, at least at night, be a means of attracting the males. Among the abundant phosphorescent organisms in the summer waters at Woods Hole small luminous points had often been shown me as phosphorescent copepods. By taking at random test tubefuls of sea water at night a single such phosphorescent point could be isolated. Such samples of sea water contained sometimes one, sometimes more copepods, but they were so frequently without copepods at all that I was forced to decide that the luminous points were something other than these animals. Moreover, when a single male or female Labidocera was put in a test tube containing sea water which on previous agitation showed no phosphorescence, and the whole vigorously shaken, not the least phosphorescence was ever observed. *Labidocera æstiva* is, in my opinion, not phosphorescent, and therefore this factor can have no part in causing the males to be attracted by the females.

Since phosphorescence seems to play no part, and since the higher sense organs of the Labidoceræ, the eyes, etc., are so very rudimentary, some form of scent would seem the most natural way by which the males might be led to the females. This would probably depend upon some substance given out by the females to which the males would react. That there probably is such a substance is seen from the following

experiments. A piece of glass tube about 2 centimeters long was filled with sea water, its ends were plugged with wet cotton, and it was wrapped in a little more than one fold of white filter paper. A thread was tied around the tube, thus holding the filter paper in place, and the apparatus prepared in this way was lowered into the surface water of a small aquarium containing five male Labidoceræ. These swam freely to and fro, and now and then collided with the tube. They were watched accurately for thirty minutes, and the number and character of the collisions noted. In all, ten collisions occurred, after each of which the animal usually deserted the tube at once. Those animals that just missed the tube in passing went on by it without special reaction. The tube was now withdrawn from the aquarium and five females were introduced into it. Because of the filter paper and the plugs of cotton these were not visible from the outside. The tube was again placed in the aquarium, and after five minutes the actions of the males were again observed for thirty minutes. Under these conditions the males collided sixteen times with the tube instead of ten. Moreover they seldom passed near the tube without some characteristic reaction. Usually they made one or two quick circles as they swam by, or even a somersault-like motion; these were observed fifteen times when the females were in the tube, never when they were not.

The experiment was now varied by dropping the small piece of tube to the bottom of the aquarium and recording the reactions of the males as before. During the half hour in which no females were in the tube, males collided with it thirteen times, but showed no inclination to play about it. After the introduction of the females eighteen collisions were observed and eight playing movements as males swam by. I am, therefore, thoroughly convinced that males respond to females even when they can not see them or come in contact with them. As the females are not known to have any power of producing sound, they probably give rise to some substance that serves as a scent for the males; in other words, the males are probably positively chemotropic toward the females.

Admitting this last conclusion, we have now all the facts needed for a satisfactory explanation of the daily migrations of Labidoceræ. The females come to the surface as daylight vanishes because they are positively phototropic to weak light and because they are negatively geotropic. They descend from the surface into deeper water at the appearance of daylight because they are so strongly negatively phototropic to bright light that they overcome their negative geotropism. The males follow the females because they are probably positively chemotropic toward them.

THEORIES OF DAILY MIGRATIONS OF PELAGIC ANIMALS.

It is now comparatively simple to discuss the more important theories advanced to explain the daily migrations of pelagic animals. Chun's (1887) hypothesis that the migration depended primarily on temperature changes is absolutely without support from what has been learned about the daily movements of *Labidocera æstiva*. Weismann's (1877) opinion that light governs the migration is very close to the truth, though it requires modification in the direction pointed out by Loeb (1894, p. 67), who, after having shown the general importance of light in the daily migrations of pelagic animals, expresses his belief "that light is not the only physical influence

that determines the depth-migrations of sea animals." This has been abundantly demonstrated in Labidocera, where geotropism and chemotropism play parts as well as phototropism, and probably much the same complexity obtains in many other organisms whose depth-migrations, though made simultaneously, may be really the results of quite different causes.

CONCLUSIONS.

1. *Labidocera æstiva* has a specific gravity in reference to pure water of 1.109, to sea water 1.082—.

2. It falls through sea water at the average rate of about half a centimeter a second (a fathom in six minutes). It swims upward at about one-third this rate.

3. In its fall it is oriented by the spread antennæ, which keep the head uppermost.

4. Its locomotor movements are either rapid uniform runs, or leaps, or rarely some intermediate form of movement.

5. The runs are accomplished by the appendages between the anterior antennæ and the tail.

6. The leaps can be carried out by the anterior antennæ, by the tail, or by these combined, but not by the other appendages except in conjunction with either anterior antennæ, or tail, or with both.

7. *Labidocera æstiva* may attach itself to fixed objects in the water by the anterior antennæ. It may also hang from the surface of the water by these organs.

8. The anterior antennæ perform at least three functions—mechanical orientation of the animal in falling, positive locomotion in leaping, and attachment to fixed objects or to the water film.

9. Males and females react in characteristically different ways to light, gravity, etc.

10. Females have a strong negative geotropism. Males have a weak negative geotropism.

11. The geotropism of Labidocera is not changed by shaking it in water or by other forms of mechanical stimulation. Increasing the density of the sea water from 1.025 to 1.035 and 1.050 increases slightly the negative geotropism of the males, but does not influence the females. Decreasing the density of the sea water from 1.025 to 1.020, 1.015, 1.010, 1.005, and 1.000 does not influence geotropism. Temperature changes between 10° and 35° C. have no influence on the geotropism of the males. The geotropism of the females is negative in cold water and positive in warm, the critical temperature being about 26° C.

12. Females have a strong positive phototropism for light of a low intensity. Males have a weak negative phototropism. The positive phototropism of the females is stronger than their negative geotropism. The phototropism of both sexes is unaltered by temperature changes between 10° and 35° C. It is also unaltered when the density of the sea water is varied from 1.050 to 1.000. Certain forms of mechanical stimulation (handling with a pipette, but not agitation in water) make females temporarily negatively phototropic and increase the natural negativity of males. Females are negative to light of high intensity (100-candle power incandescent light at 10 centimeters distance, and direct sunlight). Males are apparently indifferent to changes in light intensity.

13. Males are positive toward females and probably chemotropically positive.

14. *Labidocera æstiva* frequents the surface of the sea from sunset to sunrise. From sunrise to sunset it is presumably in deeper waters. Its migrations are explained as follows: Females rise to the surface with the setting of the sun, because they are positively phototropic to faint light and negatively geotropic; they descend into deep water with the rising of the sun, because they are negatively phototropic to strong light (their negative geotropism being overcome by their negative phototropism); the males follow the females in migration, because they are probably positively chemotropic toward the females.

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THE GAS IN THE SWIM-BLADDER OF FISHES.

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The function of the swim-bladder of fishes has attracted the attention of scientists for many centuries. The rôle that this structure plays in the life of the animal has been interpreted in almost as many ways as there have been investigators, and even now there is apparently much doubt as to the true functions of the swim-bladder. Consequently any additional data concerning this organ is of immediate scientific value.

Aristotle, writing about the noises made by fishes, states that "some produce it by rubbing the gill arches * * * ; others by means of the air-bladder. Each of these fishes contains air, by rubbing and moving of which the sound is produced." The bladder was thus considered a sound-producing organ, and it is probable that he arrived at this result by his own investigations.

Borelli* (1680) attributed to the air-bladder an hydrostatic function which enabled the fish to rise and fall in the water by simply distending or compressing the air-bladder. This hypothesis, which gives to the fish a volitional control over the air-bladder—it being able to compress or distend the bladder at pleasure—has prevailed, to a greater or less degree, from the time of Borelli to the present. To my knowledge, however, there are no investigations which warrant such a theory, while, on the other hand, there are many facts, as shown by Moreau's experiment, which directly contradict this belief. Delaroche† (1807–1809) decidedly opposed the ideas of Borelli, and yet advanced an hypothesis similar to it in many respects. Like Borelli, he said that the fish could compress or dilate the bladder by means of certain muscles, but this was to enable the fish to keep the same specific gravity as the surrounding medium and thus be able to remain at any desired depth (and not to rise and sink). This was also disproved later by Moreau. Delaroche proved that there existed a constant exchange between the air in the air-bladder and the air in the blood, although he did not consider the swim-bladder an organ of respiration.

*Borelli, De Motu Animalium, 1680.
†Delaroche, F., Annales du Mus. d'Hist. Nat., tome XIV.

Biot* (1807), Provençal and Humboldt† (1809), and others made chemical analyses of the gas in the swim-bladder and found 1 to 5 per cent of CO_2, 1 to 87 per cent of O_2, and the remainder nitrogen. The most remarkable fact discovered about this mixture was that it frequently consisted almost entirely of oxygen, the per cent of oxygen increasing with the depth of water inhabited by the fish. The reasons for this phenomenon have never been satisfactorily explained.

In 1820 Weber‡ described a series of paired ossicles which he erroneously called stapes, malleus and incus, and which connected the air-bladder in certain fishes with a part of the ear—the atrium sinus imparis. Weber considered the swim-bladder to be an organ by which sounds striking the body from the outside are intensified, and these sounds are then transmitted to the ear by means of the ossicles. The entire apparatus would thus function as an organ of hearing. Weber's views remained practically uncontested for half a century, but recently much has been written both for and against this theory. Whatever the virtues of the case may be, there is certainly an inviting field for further physiological investigations regarding this subject, and more especially on the phenomena of hearing in fishes.

Twenty years later Joh. Müller§ described, in certain Siluroid fishes, a mechanism, the so-called "elastic spring" apparatus, attached to the anterior portion of the air-bladder, which served to aid the fish in rising and sinking in the water according as the muscles of this apparatus were relaxed or contracted to a greater or smaller degree. This interpretation of the function of the "elastic spring" mechanism was shown by Sörensen‖ to be untenable. Müller also stated that in some fish, at least, there was an exchange of gas between blood and air-bladder—the latter having a respiratory function—and regarded the gas in the air-bladder as the result of active secretion. In *Malapterurus* he stated that it is a sound-producing organ.

Hasse,¶ in 1873, published the results of his investigations on the function of the ossicles of Weber, stating that their action was that of a manometer, acquainting the animal with the degree of pressure that is exerted by the gases in the air-bladder against its walls. This pressure necessarily varies with the different depths of water which the fish occupies. Hasse did not agree with Weber that the ear is affected by the movements of these ossicles.

One year later Dufossé** described in some fishes an air-bladder provided with extrinsic muscles by whose vibrations sound was produced, the sound being intensified by the air-bladder, which acted as a resonator. He also believed that certain species produced a noise by forcing the gas from the air-bladder through a pneumatic duct.

At about the same time Moreau†† published his classical work on the functions of the air-bladder. He proved by ingenious experiments that many of the prevailing ideas about the action of the air-bladder were erroneous, and that this organ serves to equilibrate the body of the fish with the water at any level. This is not accomplished quickly, but only after sufficient time for the air in the bladder to become

*Biot, Mémoires de Phys. et de Chimie de la Soc. d'Arcueil, tome I.
†Provençal et Humboldt, Mémoires de Phys. et de Chimie de la Soc. d'Arcueil, tome II.
‡E. H. Weber, De Aure et Auditi Animalium Aquatilium.
§Joh. Müller, Archiv f. Anat. u. Physiologie, 1842, pp. 307 et seq.
‖Wm. Sörensen, Journ. of Anatomy and Physiology, vol. 29, 1894–95.
¶Discussion of Hasse's theory by Sörensen, op. cit., p. 534.
**Dufossé, Annales d. Sci. Nat., 5e sér., tomes 19 and 20, 1874.
††Moreau, Mémoires de Physiologie, vol. 15, p. 494 et seq.

adjusted to the increase or decrease in external pressure that has taken place. The fish, therefore, makes no use of any muscles in regulating the volume of its air-bladder. The animal can accommodate itself only gradually to considerable changes in depth of water, but can live equally comfortably at varying depths, provided that the change has been gradual enough. Moreau's experiments also convinced him that the gas is actually secreted into the air-bladder, and that there is a constant exchange of gas between it and the blood. In these investigations he has also noticed that section of the sympathetic nerve fibers supplying the walls of the air-bladder hastens the secreting of the gas into the empty bladder. Since then Bohr* has shown that section of the vagus nerve causes the secretion to cease. Moreau noticed in one fish (*Trigla*) having an air-bladder supplied with muscles that the latter served to make the air-bladder produce sound.

Again, in 1885, the Weberian mechanism was brought to our attention with a new function attributed to it by Sagemehl,† who stated that this mechanism exists not for any auditory purposes nor to tell the animal at what level of the water it is swimming, but to indicate to the fish the variations in the atmospheric pressure. Sörensen tersely contrasts the views of Hasse and Sagemehl by saying that "Hasse considers the air-bladder with the Weberian mechanism as a manometer; Sagemehl regards it as a barometer." The theory of Sagemehl has, naturally enough, met with little favor. Sörensen‡ (1895) held that there is but little evidence for attributing to the air-bladder the function of a lung. It is to be remembered, however, that, according to Sörensen's criterion, no matter what exchange of gases takes place between blood and air-bladder, it can not be considered an organ of respiration "unless its air is renewed by mechanical respiration."

Sörensen also refutes, from anatomical and experimental grounds, the many objections to Weber's theory of the function of the ossicles. He would thus attribute to the air-bladder the function of hearing; indeed, in certain species, the only reason for the survival of the air-bladder is that "the organ is still of acoustic importance; that it acts as a resonator." This idea, Sörensen states, is borne out by the anatomical structure found in *Misgurnus* and *Clarias*, which resembles the celebrated "Colladon resonator." This author attributes to the air-bladder, with its "elastic spring" and various muscular mechanisms, the production of sound as its chief function.

From the foregoing brief historical summary of the function of the swim-bladder it is readily seen that these investigators have not thrown any direct light on the function of the gas itself which is contained in the bladder. It would, indeed, seem strange and contrary to general biological laws for certain gases to exist in the bladder and not be of any use. Why, indeed, should we find a high per cent of oxygen in the bladders of fish taken from 55 to 70 fathoms of water, especially as the gas is actively secreted§ by the fish? Such a specialized expenditure of energy would certainly not be accounted for on the basis of acoustic and phonation functions, as the normal gas composition of the surrounding medium would answer all these requirements. In the voyage of H. M. S. *Challenger*‖ it was found that "in the

*Journal of Physiology, vol. 15, p. 494 et seq.

†Journal of Anat. and Physiology, vol. 29, pp. 544 et seq.: "Theory of Sagemehl," by Sörensen.

‡Journal of Anat. and Physiology, vol. 29, pp. 109, 205, 390, and 518.

§J. S. Haldane, Science Progress, vol. 7, 1898.

‖ Challenger Reports, vol. 1, pt. 1, p. 226.

deep-sea waters the volumes of oxygen were, in general, less than those calculated from the nitrogen-volumes on the hypothesis of surface absorption of air at the temperature corresponding to the nitrogen found. In waters from great depths the actual volume of oxygen was often very small." "It is worth noting, however, that very small quantities of oxygen present themselves occasionally at moderate depths." Two examples are here given:

Cubic centimeters per liter.		O_2 calculated.	Depth (fathoms).	Per cent of O_2 in dissolved gas.
N_2.	O_2.			
15.08	0.6	8.21	2,875	4.33
13.74	1.65	7.15	300	10.72

The *Challenger* expedition did not find any deep-sea waters that were entirely free from absorbed oxygen. In the surface waters the amount of oxygen absorbed from air at a given temperature is the product of its coefficient of absorption into its partial pressure in the undissolved residue. Hence, in surface water, at given temperature and 760 mm. pressure, there would be the following result:

Temperature C.	Dissolved N_2 and O_2 in c. c.		Per cent of O_2 in dissolved gas.
	N_2.	O_2.	
0°	15.60	8.18	34.40
35°	8.36	4.17	33.31

In the first table we find the per cent of oxygen in the dissolved gases to be 4.33 per cent and 10.72 per cent respectively, which, compared with the O_2 per cent in surface waters in the second table, shows an enormous deficit. As to the free CO_2 in the sea, I quote again from the *Challenger* report: "From all the evidence afforded by the *Challenger* research we see that free carbonic acid in sea waters is the exception." It would thus seem that there is every condition offered for the elimination of CO_2 from living organism, as by the gills of fishes, and the immediate absorption of this waste product by the surrounding water. It is at least a strange coincidence that with the gradual diminution of oxygen in the water, according to the depth, we find an increase in percentage of oxygen contained in the bladder. Biot cites *Trygla lyra* from 500 fathoms containing 87 per cent oxygen; *Sparus argenteus* from 65 fathoms contained 50 per cent oxygen; *Sparus dentex* from 20 fathoms contained 40 per cent oxygen. My own observations on *Lopholatilus* taken from 55 fathoms showed 66.5 per cent oxygen, and from 70 fathoms showed 69 per cent of oxygen. May not this process be one directly to supply the animal with more oxygen under these conditions, where the oxygen dissolved in the water is so deficient? Such an explanation is tenable, inasmuch as Hüfner, Bohr, Moreau, and Haldane have shown by experiment that the gas is the result of an active secretion in which almost pure oxygen may be given to the bladder.

It occurred to me, if this process existed for the purpose of supplying oxygen to the animal, that changes in the proportion of the constituent gases would be found when the animal was partially or compietely asphyxiated, and that these changes

would be fairly constant in all fish subjected to the same conditions. The abundance of squeteague supplied by the Fish Commission Laboratory at Woods Hole furnished the opportunity for a large number of analyses under different conditions. Few analyses had been completed, however, before it was evident that the per cent of oxygen in the air-bladder was no indication of the processes taking place there. In the accompanying table the squeteague numbered 1 to 9 were allowed to become asphyxiated by dying in the open air on the wharf. The animals were very active before they were taken from the live-car. In each case the gas was analyzed at a fixed time after asphyxiation. The bladder was rapidly removed from the dead animal, and a silk ligature was tied a short distance from the small end. The end of the bladder was then amputated, and the 3-way stopper of the Bunte apparatus was inserted into the lumen and fastened by another ligature. The entire Bunte apparatus being filled with water, the first ligature was carefully cut, and the bottom stopper of the apparatus being opened, the gas from the bladder replaced the water in the instrument. The stoppers were now closed and the gas analyzed by the ordinary methods. In No. 4 there was found 17.51 per cent of oxygen, while in No. 6 there was only 6.5 per cent; yet the animals were under practically the same conditions. The amount of CO_2, considered independently of the oxygen, also shows no particular characteristic, but when compared with the oxygen it is seen to vary somewhat proportionately with the oxygen; so that, in the two above cases, the quotient of $\frac{CO_2}{O_2}$ became respectively 0.245 and 0.26. It is evident, therefore, that in all nine cases the proportion of CO_2 to O_2 is nearly constant, and thus asphyxia has produced a like effect on the gases in the bladder.

This fact naturally suggested analyses of gas taken from normal live animals. The first series were upon animals taken from the live-car and, as far as could be judged, in normal condition. The animals were taken from the water and the gas collected as rapidly as possible. The result of the analyses of this gas is given in the table, Nos. 14 to 20. Here again there is a marked difference in absolute amounts of O_2 in bladder, and also in absolute quantities of CO_2. The extreme differences are shown by comparing Nos. 14 and 20. The $\frac{CO_2}{O_2}$ coefficient, however, shows a close agreement throughout the seven specimens subjected to the same conditions. Even in these experiments the chances for partial asphyxiation were not entirely eliminated, for this would begin during the time that the gas was being collected. Another set of experiments was made on squeteague in which the gas was collected while the gills of the animals were irrigated with salt water, thus giving no possible chance for asphyxiation; the results are given in Nos. 21 to 23 of the table. In this experiment, as in the two previous ones, there are differences in absolute amounts of O_2 and CO_2 in the different specimens, but the $\frac{CO_2}{O_2}$ quotients are very nearly the same.

Another series of experiments is recorded in Nos. 10 to 13. These squeteague represented different stages of asphyxiation. None were dead, but none were very active. The result of the analysis showed a $\frac{CO_2}{O_2}$ quotient, which is especially interesting, for it varied with the condition of the animal. In No. 10 the $\frac{CO_2}{O_2}$ quotient

was 0.122, which corresponds with the series beginning with No. 14, and this animal was the most active. In No. 12 the $\frac{CO_2}{O_2}$ quotient was 0.191, which corresponds to the first series, and of the three this animal was the nearest dead.

The table records the result of the various analyses as they were made in 1900. In the summer of 1901, at my request, both Mr. E. H. Green and Mr. A. K. Krause, independently of each other, made analyses of the gas taken from animals subjected to the same conditions as described above. In both cases the $\frac{CO_2}{O_2}$ quotients fell in their respective places in the series.

If we now compare the $\frac{CO_2}{O_2}$ quotients in Nos. 1 to 9 as representing asphyxiated animals, and the quotient in Nos. 21 to 23 as representing animals in their normal condition, it will be seen that there is a great difference between them. These results indicate that there is an active respiratory process taking place in the bladder during asphyxiation.

No.	Per cent O_2.	Per cent CO_2.	$\frac{CO_2}{O_2}$.	Remarks.	No.	Per cent O_2.	Per cent CO_2.	$\frac{CO_2}{O_2}$.	Remarks.
1	14.45	3.99	0.275		14	19.00	2.30	0.121	
2	15.85	4.47	.282		15	13.30	1.28	.096	Gas removed while animals were alive, immediately after being taken from car.
3	15.80	4.70	.297	Gas taken after the animals had been asphyxiated by dying on the wharf.	16	10.08	1.26	.125	
4	17.51	4.30	.245		17	8.34	.93	.115	
5	15.91	4.20	.264		18	10	.82	.082	
6	6 50	1.60	.261		19	8.60	.62	.072	
7	15.64	4.54	.290		20	5.55	.70	.126	
8	12.20	3	.247						
9	9.70	2.90	.298		21	11.86	.75	.063	Gas taken while gills were irrigated with salt water.
10	18.80	2.30	.122	Gas removed when animals were almost dead in a crowded car.	22	12.12	.75	.061	
11	16 90	2.50	.147		23	8.77	.92	.104	
12	12.00	2.30	.191						
13	17.80	2.80	.157		24	11.40	1	.087	Spinal cord cut and gas removed.

SUMMARY.

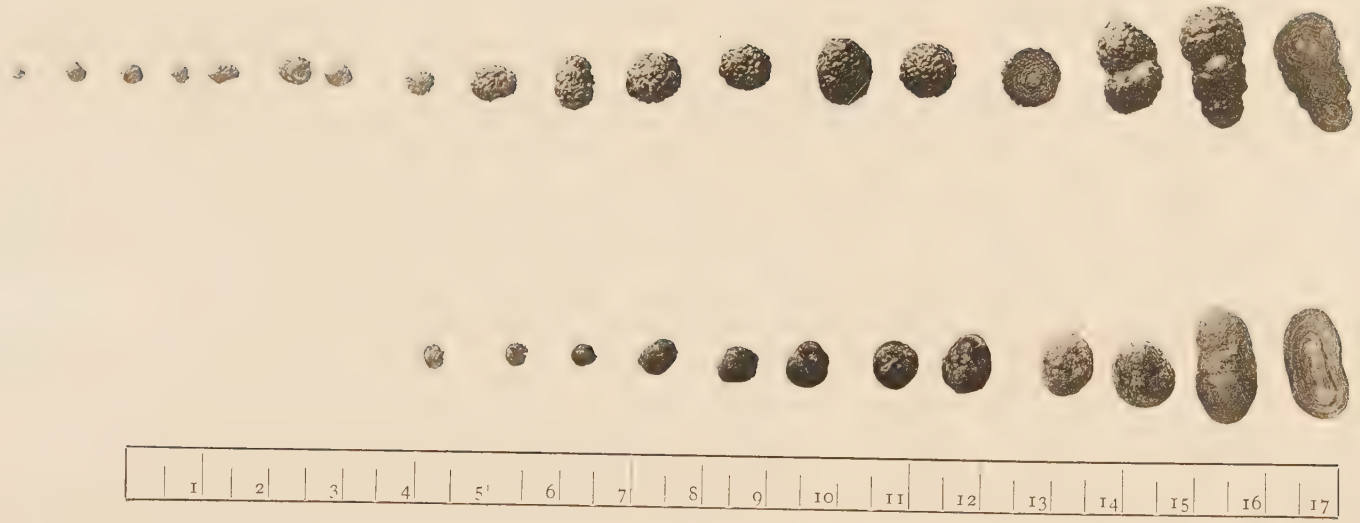
1. The evidence for exchange of gases between blood and air-bladder must be sought not in the absolute amount of O_2 or CO_2 in the bladder, but in the proportion of these two gases.

2. The $\frac{CO_2}{O_2}$ quotient of the gas in the swim-bladder of normal animals is small, ranging from 0.06 to 0.10.

3. The $\frac{CO_2}{O_2}$ quotient increases as the animal is asphyxiated, and reaches 0.24 to 0.29 when killed by this means.

4. The fact that different per cents of O_2 are found in different squeteague under the same conditions strengthens the view that the gas is a secretion; for how could we have 19 per cent in No. 14 and 5.55 per cent in No. 20 under a process of diffusion?

5. Fish (*Lopholatilus chamæleonticeps*) from 55 fathoms of water have 66.5 per cent of O_2 and only a trace of CO_2, and from 70 fathoms of water have 69 per cent of O_2 and a trace of CO_2. The deeper the water the smaller the $\frac{CO_2}{O_2}$ quotient. This goes on until pure oxygen alone is present in the air-bladder.



BILIARY CALCULI FROM SQUETEAGUE.

The stones in each group are from one fish. A centimeter scale is introduced to show their size.

THE MERIDEN GRAVURE CO.

Contributions from the Biological Laboratory of the U. S. Fish Commission,
Woods Hole, Massachusetts.

BILIARY CALCULI IN THE SQUETEAGUE.

By R. W. TOWER,
Associate Professor of Chemical Physiology, Brown University.

Pathological changes in marine animals seldom attract our attention, and it is indeed surprising that abnormal conditions are not more frequently found. The explanation of this must be either that these animals are remarkably free from disease or that the diseased individuals are quickly eliminated by the untoward conditions.

In 1901, while at the Fish Commission laboratory at Woods Hole, my attention was called to the presence of gallstones in the squeteague (*Cynoscion regalis*) by Mr. A. K. Krause, who had occasion to collect the bile from some three hundred specimens of this species during the summer. Of this number only four showed any lesions of the liver or bile passages. In one, the liver was apparently cirrhotic; from the other three, gallstones were collected and preserved for the following investigations.

The calculi in the first squeteague completely filled the gall bladder and the gall duct, in which no bile was found. These calculi (shown in the first or upper group) numbered 16 in all, weighed 2.465 grams, and were of all sizes from a big bean to a BB shot. The largest dried over sulphuric acid weighed 0.6725 grams; was 1.5 centimeters long, 0.5 centimeter thick, and 0.75 centimeter wide. All of these calculi were more or less nodulated, as can be readily seen from plate XXI. When bisected in a longitudinal plane they are found to consist of concentric layers arranged around one or more nuclei, which were very small and consisted chiefly of cholesterin. It being impossible to pulverize the air-dried stones, they were minced as fine as possible and boiled with water.

The aqueous extract (*a*) contained only a trace of either organic or inorganic matter (see p. 134). The solid residue (*b*) was extracted with hot alcohol. The alcohol (*c*) was decanted and evaporated, giving a mere trace of bile pigments, with a little cholesterin. The solid residue (*d*) was next digested with ether until there was no further extraction. The ether solution (*e*) on evaporation yielded fat and cholesterin. The latter crystallized in characteristic plates which were easily identified under the microscope. Dissolved in chloroform these crystals gave the characteristic cholesterin reaction after the addition of sulphuric acid. The solid residue (*f*) was now extracted with dilute hydrochloric acid (1:3) for 12 hours. Effervescence of CO_2 indicated the presence of carbonates, but in small amounts. The acid solution (*g*) was decanted, evaporated to dryness, and ignited. The ash dissolved readily in dilute hydrochloric acid and on analysis showed the presence of calcium, magnesium, iron,

phosphoric acid and sulphuric acid. The solid residue (*h*) from the HCl extract was washed with water and extracted several times with hot chloroform, which took out small quantities of bilirubin at each extraction (*i*). This method evidently did not remove all the pigment, so the solid residue (*j*) was extracted with hot alcohol containing a little HCl. This removed a pigment in considerable quantities (*k*) which gave the qualitative tests for bilirubin. The solid residue (*l*) was digested in ether for 12 hours, but nothing was extracted (*m*). The residue (*n*) gave strong reactions with Millon's reagent and with the xanthoproteic test. It was divided into two proportions. One portion (*o*) was oxidized with KNO_3 and Na_2CO_3 and tested for phosphoric and sulphuric acids. Both were positive. A control test with the reagents alone gave no reaction. The other portion (*p*) was boiled with dilute hydrochloric acid for two hours. The resulting solution was examined for reducing sugars, but with negative results. It would seem, then, from the above that the proteid substance was of the nature of a nucleo-albumin and not a mucin. (See Table I.)

The small amount of calculi in the first or upper group (plate XXI) not used in the preceding analysis was estimated quantitatively for the principal constituents, with the following results:

Calculi dried to constant weight over H_2SO_4.

	Per cent.
Cholesterin and fat	2.85
Mineral	3.65
Bilirubin	16.14
Nucleo-albumin	65.59
Water	11.52
Soluble in water	Trace.
	99.75
Total ash of calculi	4.32

The fat was in excess of the cholesterin, although a quantitative separation was not made.

The calculi in the second group (plate XXI) were from another squeteague (a male). They differed from the first lot in being smoother and less nodulated. When bisected longitudinally they exhibited the same concentric structure as the others. These stones were found not only in the gall bladder and gall ducts, but also in the intestines, and, strangely enough, were embedded in the tissues between the liver and intestines. No lesions or scars appeared either in the bile ducts or in the intestines, yet these stones must have broken through the walls of these passages at some earlier time. The gall bladder and duct contained a small quantity of bile.

There were in all eleven stones, weighing 1.865 grams. The largest dried over sulphuric acid weighed 0.645 grams, was 1.7 cm. long, 0.8 cm. wide, and 0.7 cm. thick. The qualitative analysis agreed with the preceding and was carried out in the following way: The dried substance, finely minced, was extracted with ether until nothing more was dissolved. The ether extract (1) on evaporation contained cholesterin and a small amount of fat (see p. 135). The residue (2) was digested with dilute (2 per cent) hydrochloric acid for 12 hours, giving a slight effervescence of CO_2. The extract (3) on evaporation showed but little residue and was united with (5) for further analysis. The residue (4) was now extracted four hours with warm dilute HCl, which removed most of the mineral matter. The extract (5) was analyzed directly for inorganic substances. This gave relatively large quantities of phosphoric acid,

calcium, and magnesium, smaller quantities of sulphuric acid, and a slight amount of iron. The residue (6) was extracted with hot chloroform, and the extract (7) upon evaporation gave but little bilirubin. The residue (8) was boiled with alcohol. The alcohol extract (9) when evaporated gave a small amount of bilirubin. Thinking that there might be yet a bilirubinate which had not been decomposed by the dilute HCl, the residue (10) was extracted with hot dilute HCl alcohol for three hours. The acid-alcohol extract (11) upon evaporation yielded a considerable quantity of pigment which had the properties of bilirubin. A portion of the residue (12) gave strong reactions with Millon's reagent and by the xanthoproteic test. The remainder was divided into two portions. The smaller (14) was fused with KNO_3 and $HNaCO_3$ in order to determine the presence of P and S in the organic molecule. The product dissolved in hot dilute nitric acid gave good reactions for phosphoric and sulphuric acids. The larger portion (13) was washed, dried to constant weight at 105°C., and the per cent of N estimated by the Dumas method. An accident at the close of the determination prevented an accurate estimation. There was at this time 13+ per cent N. The estimation, being of necessity low, can not be taken as an absolute indication of the nature of the substance, yet it would seem to suggest a nucleo-albumin rather than a mucin. (See Table II.)

The quantitative analysis of these calculi dried to constant weight at 100° C. yielded:

	Per cent.
Cholesterin (and fat)	0.17
Bilirubin	22.39
Nucleo albumin	70.69
Mineral	5.10
	98.65

The difference in per cent of fat and cholesterin in the two analyses is certainly striking. The amount of cholesterin in the two cases varied but little as far as could be determined by qualitative reactions, but the fat in the latter case was evidently very much less.

The gallstones in the third or lower group, taken from the third squeteague (a female), were much smaller than the preceding. The largest, dried over sulphuric acid, weighed 0.11 gram and the entire 24 weighed only 0.935 gram. The appearance, except size, did not differ from No. 2. The calculi were also found in the gall bladder, gall duct, intestines, and embedded in the tissues surrounding the intestines and liver. The gall bladder contained a quantity of bile. The qualitative analysis did not differ from the two preceding, and a quantitative determination was not made.

The three fish from which the above calculi were taken were apparently in normal condition as far as could be determined when taken from the water. The livers were perfectly normal in appearance. It is a difficult matter to collect the urine from these animals, as it is generally eliminated as soon as they are taken from the water; but the small quantity of urine that was collected showed the presence of no bile pigments. Observations of this character would certainly be of interest in the light of comparative physiology.

Perhaps the most interesting feature in the analyses described above is the high per cent of nucleo-albumin, differing in this respect from the gallstones reported from other animals. Further observations on the formation of these calculi might prove to be of value in explaining the causes of such deposits.

TABLE I.

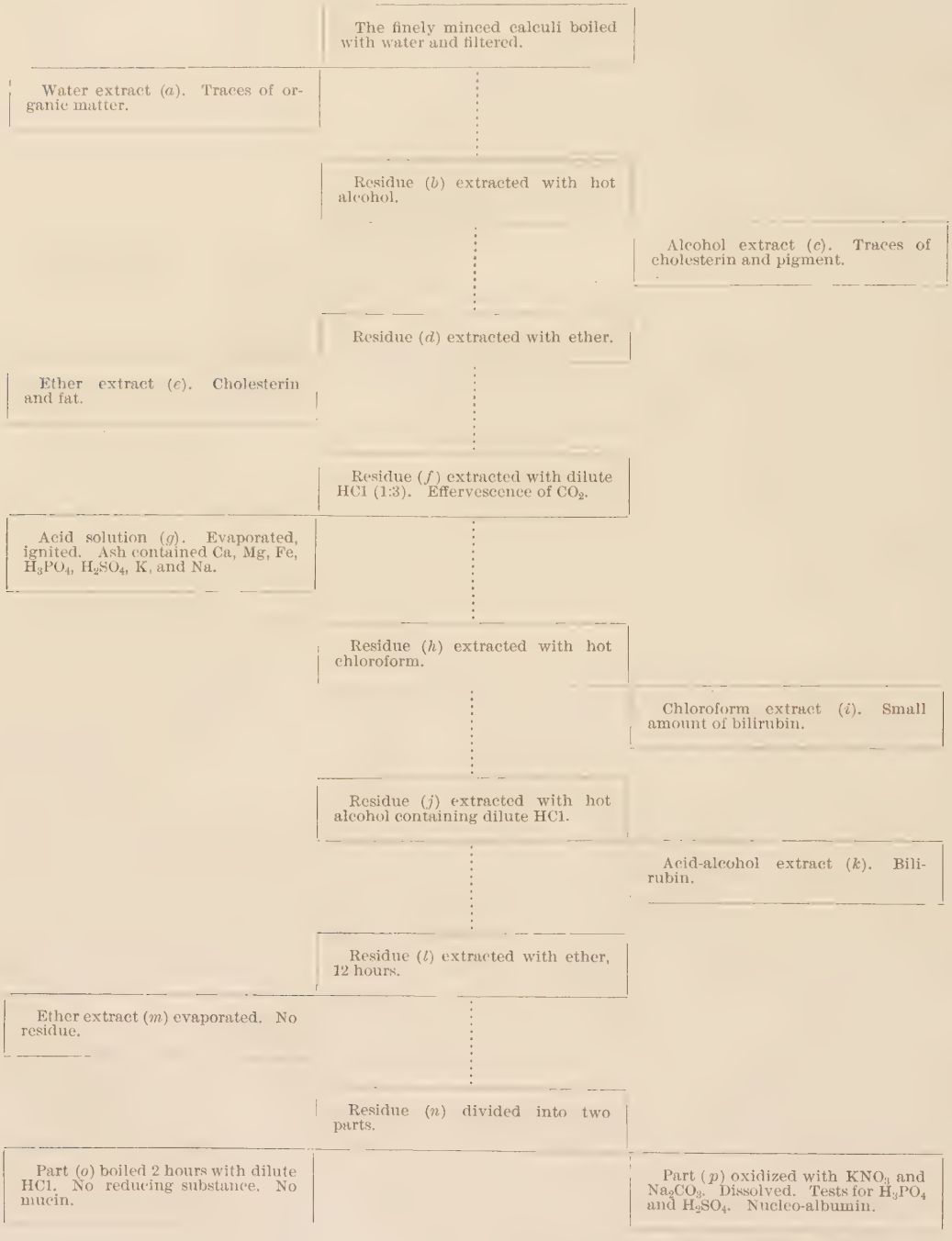
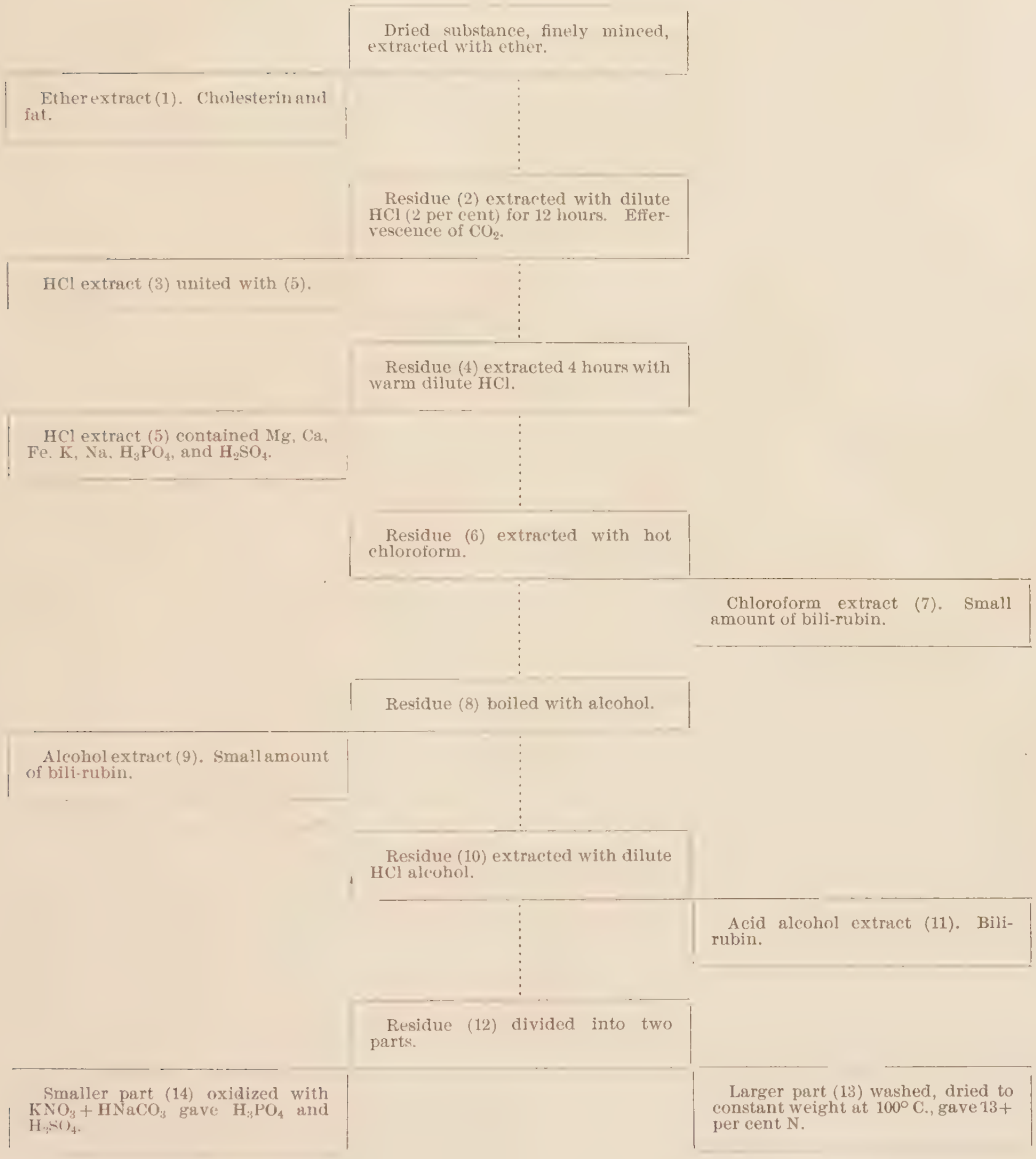

The finely minced calculi boiled with water and filtered.
Water extract (a). Traces of organic matter.
Residue (b) extracted with hot alcohol.
Alcohol extract (c). Traces of cholesterin and pigment.
Residue (d) extracted with ether.
Ether extract (e). Cholesterin and fat.
Residue (f) extracted with dilute HCl (1:3). Effervescence of CO_2.
Acid solution (g). Evaporated, ignited. Ash contained Ca, Mg, Fe, H_3PO_4, H_2SO_4, K, and Na.
Residue (h) extracted with hot chloroform.
Chloroform extract (i). Small amount of bilirubin.
Residue (j) extracted with hot alcohol containing dilute HCl.
Acid-alcohol extract (k). Bilirubin.
Residue (l) extracted with ether, 12 hours.
Ether extract (m) evaporated. No residue.
Residue (n) divided into two parts.
Part (o) boiled 2 hours with dilute HCl. No reducing substance. No mucin.
Part (p) oxidized with KNO_3 and Na_2CO_3. Dissolved. Tests for H_3PO_4 and H_2SO_4. Nucleo-albumin.

TABLE II.


Dried substance, finely minced, extracted with ether.
Ether extract (1). Cholesterin and fat.
Residue (2) extracted with dilute HCl (2 per cent) for 12 hours. Effervescence of CO_2.
HCl extract (3) united with (5).
Residue (4) extracted 4 hours with warm dilute HCl.
HCl extract (5) contained Mg, Ca, Fe, K, Na, H_3PO_4, and H_2SO_4.
Residue (6) extracted with hot chloroform.
Chloroform extract (7). Small amount of bili-rubin.
Residue (8) boiled with alcohol.
Alcohol extract (9). Small amount of bili-rubin.
Residue (10) extracted with dilute HCl alcohol.
Acid alcohol extract (11). Bili-rubin.
Residue (12) divided into two parts.
Smaller part (14) oxidized with $KNO_3 + HNaCO_3$ gave H_3PO_4 and H_2SO_4.
Larger part (13) washed, dried to constant weight at 100° C., gave 13+ per cent N.

A REPORT ON FISHES COLLECTED IN MEXICO AND CENTRAL AMERICA, WITH NOTES AND DESCRIPTIONS OF FIVE NEW SPECIES.

By BARTON WARREN EVERMANN and EDMUND LEE GOLDSBOROUGH.

During the past ten years Messrs. E. W. Nelson and E. A. Goldman, of the Division of Biological Survey, Department of Agriculture, have spent much time in Mexico and Central America making collections of mammals and birds. Incidental to their regular work these gentlemen have been able, from time to time, to make several small collections of fishes, which have been referred to the Commission of Fish and Fisheries for identification. Certain of these collections* have already been reported upon.

In April and May, 1900, Mr. Nelson and Mr. Goldman made a considerable collection in the State of Tabasco at Montecristo and Teapa. The specimens from Montecristo came from the Rio Usumacinta, and those from Teapa from the Rio Teapa. A few specimens were obtained at Frontera, on the Gulf of Campeche, at the mouth of the Rio Grijalva.

Montecristo is situated on the Rio Usumacinta some 125 miles from the sea. This is the largest river in Mexico, it being about 300 yards from bank to bank at Montecristo. The fishes obtained at this place were secured by means of a seine hauled in a shallow cove behind a sand bar. The seine was hauled at night, and several species obtained. The fishermen say that in the daytime the fish remain in the deeper water of the river, coming out into shallow water only during the night. The collection from this place contains 21 specimens, representing 10 species, the most interesting of which are 2 specimens of a new species of bagre or cat-fish belonging to a genus (*Conorhynchos*) not previously known to be represented in waters north of Brazil, and a specimen of the fresh-water drum (*Aplodinotus grunniens*).

Teapa is at the base of the mountains on the Rio Teapa, a tributary of the Rio Tapijulapa, about 125 miles inland. Eight specimens of fishes were obtained here, representing 6 species, among them a new species of *Cichlasoma*.

In February and March, 1901, another interesting collection was made by Messrs. Nelson and Goldman in Yucatan, chiefly at Chichen Itza, Progreso, Puerto Murelos, Mujeres Island, and Cozumel Island.

Chichen Itza is an interesting hacienda in the interior of Yucatan, about 140 miles from the sea. In this region, as well as elsewhere over the greater part of Yucatan and northern Campeche, there are no streams or surface water of any kind,

*Notes on Fishes collected by E. W. Nelson on the Tres Marias Islands, and in Sinaloa and Jalisco, Mexico, by Barton Warren Evermann. <Proc. Wash. Biol. Soc., XII, pp. 1-3, 1898 (January 27).

Notes on a collection of Fishes from Mexico, with description of a new species of Platypœcilus, by Barton A. Bean. <Proc. U. S. N. M., XXI, 1898, 539-542.

except occasional natural surface tanks in which some water is found. The entire country is, however, underlaid by water approximately at sea level. At various places over the country are natural wells, called "cenotes." These are natural excavations in the limestone rock, usually with more or less water at the bottom. The distance from the surface of the country down to that of the water in the cenotes seems to vary with the elevation of the country above sea level. Near the seashore, where the elevation of the country is but a few feet above the sea, the water in the cenotes will be only a few feet beneath the land surface. The elevation of the country increases toward the interior and the depth at which the water stands in the cenotes becomes correspondingly greater. These wells are usually approximately circular and vary from a few feet to 50 to 75 yards in diameter. The walls are more or less perpendicular, and it is difficult to reach the water; however, it is usually possible to find irregularities or steps in the wall, on at least one side, by means of which the water may be reached. Frequently the wells are wholly inaccessible. Sometimes the well is in a sink or cave.

In some wells the water is quite shallow, while in others it is of unknown depth. The water usually appears green, as in all limestone regions, but in some shallow wells it seems to be somewhat muddy. There is usually a thin coating of fine dust on the surface of the water which becomes readily noticeable on throwing any object into it. The water is said to be pure and sweet, but strongly charged with lime. There is a belief prevalent among the natives that these wells are connected. However this may be, the presence of fish in them is a most interesting fact for which it is not easy to account. How old the cenotes are can, of course, be known only approximately, but they have certainly been in existence a long time.

The well at Chichen Itza from which fishes were obtained is nearly circular, probably 60 yards across, and very deep, the water surface being about 90 feet below the land surface. Mr. Goldman states that he has seen fishes in several different wells on the east coast near Puerto Morelos, and that the natives say there are fish in all the larger ones. The only species thus far obtained from these wells is *Heros urophthalmus*, 7 specimens of which were obtained by Mr. Nelson from the Chichen Itza cenote. Mr. Goldman thinks the fish he saw were of this species. Mr. Nelson heard that cat-fish occur in a well at Chichen Itza, but did not see any specimens.

According to the natives the fish in these cenotes disappear at intervals and return again. At certain times they can neither be seen nor caught; at other times they may not only be caught, but are seen swimming about at the surface.

At the time of Mr. Nelson's visit, which was during the second week in February, none could be caught, and the natives said they were away. The seven specimens obtained had been secured previously, perhaps a year or two before, and kept in a large masonry water-tank which was supplied with water by a wind pump. They had been caught by means of hook and line baited with pieces of meat. They had apparently bred in the tank, as many very young ones were seen swimming about.

Another lot of fishes, chiefly salt-water species, was obtained at Progreso, which is on the north coast of Yucatan, only a few miles from Merida, the principal town. Some were obtained from fishermen, while others, chiefly Cyprinodonts, were seined in a small lagoon; others were gotten at Puerto Morelos, situated on the east coast of Yucatan. Some five or six species were obtained here from the sea, and a lot of the smaller species from a small lagoon.

Mujeres Island, about 3 miles off the east coast of Yucatan and about 40 miles north of Cozumel Island, is about 6 miles long and one-fourth to 1½ miles wide. It is separated from the mainland by shallow water, and is headquarters for the fishermen of this coast. The fishes obtained here came from a small salt-water lagoon.

At Cozumel Island, some 8 to 10 miles off the east coast of Yucatan and about 40 miles south of Mujeres Island, only a few salt-water fishes were obtained.

Various other small collections from Mexico have come into our hands from time to time, which we have studied in connection with the preparation of this paper. There is, first, a collection of 50 specimens representing 5 species obtained by Mr. Nelson in July and August, 1899, from the Rio Piedras Verdes and Lake Santa Maria, in Chihuahua, and 5 specimens representing 4 species collected at the same time in the Rio Piedras Verdes by Prof. C. H. Tyler Townsend and Mr. C. M. Barber, of Mesilla Park, N. Mex. We have also 2 species of *Chirostoma* obtained in the market at Guadalajara in 1899, 3 species gotten in Lake Lerma at Lerma, State of Mexico, in 1901, and one species bought in the market at Yautepec, State of Morelos, in 1901, all from Dr. J. N. Rose. Then there are a few specimens representing 4 species which we have received through the kindness of Mr. Charles C. Deam, of Bluffton, Ind., who collected them in December, 1898, at Salina Cruz, Gulf of Tehuantepec; and lastly, 2 specimens of the very interesting species *Anableps dowii*, obtained by Mr. Nelson in April, 1896, from the Tehuantepec River at Tehuantepec City.

All of these collections are reported upon in the present paper.

The nomenclature and sequence of species in the following annotated list is that of Jordan & Evermann's Fishes of North and Middle America:*

1. Rhinobatus lentiginosus Garman. *Guitarro.*

One specimen, 18.5 inches long, from Progreso, Yucatan, February 28, 1901. This is the most southern record for the species.

2. Lepisosteus tropicus (Gill). *Tropical Gar Pike.*

One specimen, 20 inches long, from Montecristo. Head 3.5; depth 9; eye 10.5; snout 1.75; lower jaw 2; interorbital 4; D. 5; A. 7; V. 6; P. 12; scales 53, 17 rows from base of ventral upward and forward to and including median dorsal row. Body rather short and stout; snout short and broad, its length less than half that of head; upper jaw the longer; teeth sharp, those of upper jaw in 2 lateral rows; enlarged teeth of lower jaw in one row; eye small; fins moderate, origin of dorsal slightly behind that of anal; first dorsal ray about 1.5 in snout, with numerous small, sharp, supporting spines in 2 rows on each side; similar supporting spines on all the fins; anal high, its longest ray 1.3 in snout. Color in alcohol, leaden silvery or plumbeous above, white on belly; no spots on body except a large one at base of caudal fin and 2 or 3 smaller indistinct ones in front of it; rays of dorsal, caudal, and anal dusky, the membranes pale; pectorals and ventrals pale.

3. Felichthys marinus (Mitchill). *Gaff-topsail; Sea Cat-fish.*

Two specimens, 10 and 12.75 inches long, from Progreso. Head 3.5 and 3.86; depth 4; eye 5; snout 4 25; interorbital 1.5; D. I, 7; A. II, 20 or 21. The head is larger and the anal has 2 or 3 fewer rays than those heretofore recorded.

4. Galeichthys felis (Linnæus). *Sea Cat-fish.*

Two specimens, 9.5 and 10 inches long, from Progreso. Head 3.5; depth 5.5; eye 6; snout 3; interorbital 2.25; D. I, 7; A. 13 or 14; maxillary barbels reaching base of pectoral.

*The Fishes of North and Middle America: A Descriptive Catalogue of the Species of Fish-like Vertebrates found in the Waters of North America, north of the Isthmus of Panama, by David Starr Jordan and Barton Warren Evermann; issued as Bulletin No. 47, U.S.N.M., 4 vols., pp. I-XXIV+1-1240, 1896; I-XXX+1241-2183, 1898; I-XXIV+2183a-3136 1898; and I-CI+3137-3313, plates I-CCCXCII, 1900.

5. Conorhynchos nelsoni, new species. *Bagre.*

Type, No. 50001, U.S.N.M., a male, 16 inches long, collected May 8, 1900, by E. W. Nelson and E. A. Goldman, in the Rio Usumacinta, Montecristo, Yucatan. Cotype, No. 2382, U. S. F. C. reserve series, a male 13.5 inches long, collected at same time and place.

Head 3.2; depth 5; eye 8; snout 2.1; interorbital 3; D. I, 6; A. 17; gillrakers 10+4, short and weak, longest scarcely greater than diameter of pupil; gill-arches very convex. Body nearly terete, gradually tapering and becoming somewhat compressed posteriorly; width above pectorals not quite equal to depth; head conic, about as wide as deep at any point, a granular saddle over occipital region extending anteriorly to posterior portion of eye; a small granular saddle at base of dorsal in front, posterior edge concave; fontanelle long and narrow, beginning an eye's diameter in front of eye and extending an equal distance behind eye, a narrow transverse bridge equal to diameter of pupil just back of posterior border of eye; snout very long, pointed; mouth small, nearly circular, upper jaw the longer; barbels all very short; maxillary barbel not nearly reaching eye, its length about 2 in snout; other barbels shorter; no teeth on vomer and palatines; teeth on upper jaw confluent in one broad patch, concave posteriorly; teeth of lower jaw very weak; buccal cavity very large; roof of mouth dome-shaped; eye high, its lower edge on a line with upper part of gill-opening, its distance from end of snout equal to distance from center of pupil to gill-opening; origin of dorsal midway

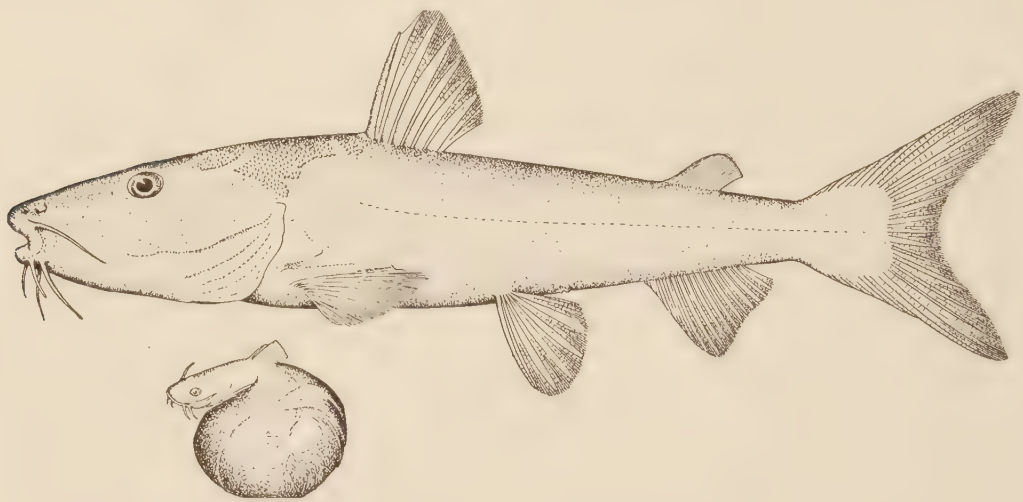


FIG. 1.—*Conorhynchos nelsoni*, new species. The smaller figure is nearly natural size, the other one-third natural size.

between tip of snout and posterior base of anal; dorsal spine of moderate strength, 2.16 in head, slightly granulated along its lower front for half its length, upper posterior third roughly serrated; the first soft dorsal ray about as high as body; distance between dorsal and adipose fins 1.4 in head; adipose fin large, its height 2.25 in that of dorsal fin, its base equal to that of soft portion of dorsal; caudal deeply forked, the upper lobe the longer, equal to snout and eye; ventral rays shorter than pectoral rays; pectoral fin moderate, its longest ray more than half head, its spine stouter than dorsal, 2.5 in head, its posterior edge very strongly serrate; anal large, its longest ray 2.75 in head.

General color in alcohol, light brown above lateral line, with bluish reflections; silvery below, becoming pale on belly; dorsal pale dusky, spine darker in front; adipose fin color of its dorsal region; caudal pale with some indications of yellow at its base and sides, inner edge of lobes tipped with black; anal pale; ventrals pale, slightly dusky inside; pectoral pale, dusky on inner side.

When the type specimen was obtained by Mr. Nelson there were found in its mouth 39 well-developed eggs. The cotype, also a male, contained one egg in its mouth.

This habit of certain cat-fishes of carrying their eggs in the mouth is a curious and very interesting one, a habit about which more or less has been known for many years.

The first and most complete account of this habit of cat-fishes carrying their eggs in their mouths is that by Dr. Jeffries Wyman, which he communicated to the Boston Society of Natural History at its

meeting of September 15, 1857. In 1859, in a paper entitled "On some unusual modes of gestation,"* Dr. Wyman published a full account of his observations as follows:

"Among the Siluroid fishes of Guiana there are several species which, at certain seasons of the year, have their mouths and branchial cavities filled either with eggs or young, and, as is believed, for the purpose of incubation. My attention was first called to this singular habit by the late Dr. Francis W. Cragin, formerly United States consul at Paramaribo, Surinam. In a letter dated August, 1854, he says:

"'The eggs you will receive are from another fish. The different fishermen have repeatedly assured me that these eggs in their nearly mature state are carried in the mouths of the parent till the young are relieved by the bursting of the sac. Do you either know or believe this to be so, and, if possible, where are the eggs conceived and how do they get into the mouth?'

"In the month of April, 1857, on visiting the market of Paramaribo, I found that this statement, which at first seemed to be very improbable, was correct as to the existence of eggs in the mouths of several species of fish. In a tray of fish which a negro woman offered for sale, I found the mouths of several filled with either eggs or young, and subsequently an abundance of opportunities occurred for repeating the observation. The kinds most commonly known to the colonists, especially to the negroes, are *jara-bakka*, *njinge-njinge*, *koepra*, *makrede*, and one or two others, all belonging either to the genus *Bagrus* or one nearly allied to it. The first two are quite common in the market and I have seen many specimens of them; for the last two I have the authority of negro fishermen but have never seen them myself. The eggs in my collection are of three different sizes, indicating so many species, one of the three having been brought to me without the fish from which they were taken.

"The eggs become quite large before they leave the ovaries, and are arranged in three zones corresponding to three successive broods, and probably to be discharged in three successive years; the mature eggs of a jara-bakka 18 inches long measure three-fourths of an inch in diameter; those of the second zone, one-fourth; and those of the third are very minute, about one-sixteenth of an inch.

"A careful examination of eight specimens of njinge-njinge about 9 inches long gave the following results.

"The eggs in all instances were carried in the mouths of the males. This protection, or gestation of the eggs by the males, corresponds with what has been long noticed with regard to other fishes, as, for example, *Syngnathus*, where the marsupial pouch for the eggs or young is found in the males only, and *Gasterosteus*, where the male constructs the nest and protects the eggs during incubation from the voracity of the females.

"In some individuals the eggs had been recently laid, in others they were hatched and the fœtus had grown at the expense of some other food than that derived from the yolk, as this last was not proportionally diminished in size, and the fœtus weighed more than the undeveloped egg. The number of eggs contained in the mouth was between twenty and thirty. The mouth and branchial cavity were very much distended, rounding out and distorting the whole hyoid and branchiostegal region. Some of the eggs even partially protruded from the mouth. The ova were not bruised or torn as if they had been bitten or forcibly held by the teeth. In many instances the fœtuses were still alive, though the parent had been dead for many hours.

"No young or eggs were found in the stomach, although the mouth was crammed to its fullest capacity.

"The above observations apply to njinge-njinge. With regard to jarra-bakka, I had but few opportunities for dissection, but in several instances the same conditions of the eggs were noticed as stated above; and in one instance, besides some nearly mature fœtuses contained in the mouth, two or three were squeezed apparently from the stomach, but not bearing any marks of violence or of the action of the gastric fluid. It is probable that these found their way into that last cavity after death, in consequence of the relaxation of the sphincter which separates the cavities of the mouth and the stomach. These facts lead to the conclusion that this is a mouth gestation, as the eggs are found there in all stages of development, and even for some time after they are hatched.

"The question will be very naturally asked, how under such circumstances these fishes are able to secure and swallow their food. I have made no observations bearing upon such a question. Unless the food consists of very minute particles it would seem necessary that during the time of feeding the eggs should be disgorged. If this supposition be correct, it would give a very probable explanation of the only fact which might be considered at variance with the conclusion stated above, viz, that we

*Am. Jour. Science and Arts, second series, XXVII, May, 1859, 5–13. This paper was communicated to the Boston Society of Natural History September 15, 1857.

have in these fishes a mouth gestation. In the mass of eggs with which the mouth is filled I have occasionally found the eggs, rarely more than one or two, of another species. The only way in which their presence may be accounted for, it seems to me, is by the supposition that while feeding the eggs are disgorged, and as these fishes are gregarious in their habits, when the ova are recovered the stray egg of another species may be introduced into the mouth among those which naturally belong there."

One of the earliest accounts of this curious habit which we have seen is that by Dr. Gunther* in which he says, referring to specimens of *Arius fissus* from Cayenne received from Prof. R. Owen:

"These specimens having had the cavity of the mouth and of the gills extended in an extraordinary manner, I was induced to examine the cause of it, when, to my great surprise, I found them filled with about twenty eggs, rather larger than an ordinary pea, perfectly uninjured, and with the embryos in a forward state of development. The specimens are males, from 6 to 7 inches long, and in each the stomach was almost empty.

"Although the eggs might have been put into the mouth of the fish by their captor, this does not appear probable. On the other hand, it is a well-known fact that the American Siluroids take care of their progeny in various ways; and I have no doubt that in this species and in its allies the males carry the eggs in their mouths, depositing them in places of safety, and removing them when they fear the approach of danger or disturbance."

The following extract is from an interesting article "On the air-breathing fish of Ceylon" by Rev. Principal Boake, published in the Journal of the Ceylon Branch of the Royal Asiatic Society for 1865–66 (1866) pages 128–142, the extract occupying pages 138–142:

"Having occasion to visit Caltura periodically, I was told on one of my visits of a fish which is caught at certain seasons in very large quantities, and which has the singular habit, when held up by the tail, of emitting from the mouth a quantity of eggs. So great is the number thus emitted that when many fish are captured the eggs are eagerly collected from the bottoms of the boats and carried away to be fried, and are greatly relished by the villagers when so prepared, while the fish themselves, being too numerous to be consumed in their fresh state, are salted and dried, and often form an ingredient in the curries which appear at our tables.

"The description which I received of the manner in which the eggs are procured seemed to point to the conclusion, universally believed by the natives, that the regular mode of bringing forth their young is, in the case of these fish, through the mouth; a fact which seemed to me to be so singular that I determined to stay a day or two longer at Caltura when I next visited it, for the purpose of investigating the circumstances which seemed to indicate so singular a conclusion.

"The result of my investigation was, as might have been expected, that I ascertained that the circumstances had not been fully or accurately observed, and consequently that the conclusion to which they pointed was erroneous; but I, at the same time, satisfied myself of a fact in the natural history of those fish, which will perhaps be regarded as but little less extraordinary than their novel mode of parturition would have been, if it had been established as true, and which, as Ceylon has acquired some notoriety for marvelous stories respecting its zoology, I should feel some hesitation in stating, were it not that, in addition to the abundance of unexceptionable testimony, I was able to procure specimens illustrating the whole extraordinary process.

"These fish produce their eggs in the first instance very much in the same manner as other inhabitants of the waters do, with this exception, that the eggs seem to come to maturity in batches of ten or twelve. Bottle No. 1 will illustrate this. It contains the roe of one out of a large number of fish that I examined. You will perceive that, besides eight or ten large eggs, there is a whitish mass, which, on being closely examined, will be found to consist of other eggs of very minute size; the difference in size between those which are ready for emission and the others which are immature being very remarkable. The strange fact, however, is that the large eggs on being emitted are immediately taken up, either by the fish that has laid them or by another of the same species, and, not swallowed, but kept in the mouth until they are hatched and the fry are able to take care of themselves, a period of some weeks, during which it is impossible that the fish, which is swimming about with so extraordinary a mouthful, can swallow any food except such small nutritious particles as may be floating about in the water. When these fish first make their appearance at Caltura, in the beginning of the

*Catalogue of the Fishes in the British Museum, by Albert Günther, v, 1864, p. 173.

season, they are said to be so fat that the curry made with them resembles that made with pork; but after swimming about for a few days, with their mouths full of eggs, they become dry and insipid. In bottle No. 2 you will see thirteen eggs, which I shook out with my own hands from the mouth of a fish 8 or 9 inches long, each egg being about the size of a small grape. Preserved in that manner, viz, in glycerin, the eggs retain their natural color and transparency, whereas in spirit they soon become opaque. In the same bottle are some other eggs which were obtained by pressure, and which present the same remarkable difference in size as those in No. 1. You will perceive that these latter are perfectly transparent, the smaller ones being scarcely visible, whereas those which were shaken out of the mouth of the fish contain a perfectly formed embryo and have a system of blood vessels spreading over their surface on one side. In bottle No. 3 you will see one of the eggs in a more advanced stage of development. Both the head and tail of the embryo have escaped from the egg, which, very little diminished in size, remains appended to the middle of the fish, giving it a very distorted appearance.

"This adherence of the egg to the young fish after it has been hatched is not peculiar to this species. The same thing occurs in the case of the salmon fry, which are being produced, under the auspices of Mr. Buckland and other eminent pisciculturists, in such quantities as to give us some grounds for hoping that that delicious fish may become again so common in the rivers of England that it shall no longer be a luxury accessible only to the wealthy, and that farm laborers may again, as is said to have been formerly the case in the neighborhood of Newcastle, find it necessary to stipulate in their engagements with their employers that they shall not be fed on salmon on more than two days in the week.

"This is the only specimen I was able to procure in that stage of development, the time not having then arrived for the general hatching of the eggs; but an intelligent friend, who is at Caltura at present, has promised to procure me other specimens, which will, I trust, enable me to ascertain a fact which I am inclined to believe, although I am not as yet prepared to assert it positively, namely, that the egg so appended is, in fact, the stomach of the animal in the state of enormous distention, and that, as its contents are absorbed while the other parts of the fish grow in size, it gradually assumes a more natural proportion to the rest of the body. To this conclusion I am led by observing the system of blood vessels, which is perceptible on the side of the egg opposite the embryo, and which certainly looks as if it was intended to form part of the organization of the future fish. I have since ascertained, by the aid of William Ondaatje, esq., assistant colonial surgeon, that the fish which carry the eggs, and subsequently the young fry, for so long a time in their mouths, are all males.

"The name by which these fish are known to the natives is *Anguluwa*. They are regarded by them as all belonging to the same species, nor would an unscientific observer be likely to discover any specific difference between any of the specimens that I have seen; but having sent several specimens to F. Layard, esq., I received a letter from him in August last, in which he informed me that he had submitted the specimens which I sent him to Dr. Günther, of the British Museum, who had ascertained that they belong to two distinct species, both new, of the genus *Arius*. Mr. Layard further tells me that the carrying of the ova in the mouth is not so novel a phenomenon as I supposed it to be, Dr. Günther having described that peculiarity in the propagation of the genus *Arius* several years ago, from South American species."

It appears that the Rev. Bancroft Boake sent some of his specimens to the botanist, Dr. Greville, who in turn transmitted them to William Turner, who published the following account* concerning them:

"The various plans resorted to by fish of depositing their ova, and protecting them during the period of incubation, have not infrequently attracted the attention of naturalists. One of the most curious and interesting observations made on this subject was brought before the Boston Society of Natural History about nine years ago, by Dr. Jeffries Wyman. He states† that when walking through the market of Paramaribo, in Dutch Guyana, he found the mouths of several species of Siluroid fish belonging to the genus *Bagrus*, or to one closely allied, distended with ova, sometimes between twenty and thirty in number. The eggs were in various stages of development, some recently deposited,

*On a remarkable mode of gestation in an undescribed species of *Arius* (*A. boakeii*), by William Turner, M. B. (Lond.), F. R. S. E., senior demonstrator of anatomy, University of Edinburgh. <Journ. Anat. and Phys., vol. I, 1867, pp. 78–82. Read before the British Association for the Advancement of Science, August 23, 1866.

†Proceedings of Boston Society of Natural History, Sept. 15, 1857, and American Journal of Science, vol. LXXVI, 1859.

others with the embryo very considerably advanced. The eggs were always in the mouths of males, and were not bruised, and none was found in the stomach. In the fifth volume of his Catalogue of Fishes in the British Museum* Dr. Günther relates that, whilst examining some specimens of *Arius fissus* from Cayenne, presented to the Museum by Professor Owen, he was surprised to find their mouths and gill chambers distended with about twenty eggs rather larger than an ordinary pea. The eggs were perfectly uninjured, and the embryos in a forward state of development. These specimens were also males.

"Again, Professor Agassiz, writing from the river Amazon, September 22, 1865,† states that he had observed a species of *Geophagus*, *G. pedroinus*, a fish belonging to the family *Chromidæ*, in which the mouth and a pocket-like pouch, formed by the superior pharyngians, contained a number of ova. How the eggs get into the mouth he is quite ignorant, but there they remain until the young are in a fit state to take care of themselves. In all the above cases the fish are denizens of the South American Continent, and, except the species described by Agassiz, belong to the Siluroid family.

"The observations to which I shall now direct attention prove that this remarkable egg-carrying habit is not confined to certain species of fish dwelling in the New World, but is shared by some of the fish of the Old World also. In the month of April of the present year I received for examination, from the eminent botanist, the late Dr. Greville, some specimens of Siluroid fish, which had been sent him by the Rev. Bancroft Boake, of Ceylon. The specimens were accompanied by a copy of the literary supplement to the Ceylon Examiner, to which Mr. Boake had communicated 'An account (dated April 20, 1865) of some peculiarities in the habits of certain species of fish that are found in the waters of Ceylon.' The most interesting portion of this narrative consists of an account of the habit of a fish caught at Caltura, in that island. When held up by the tail it emits from the mouth a quantity of eggs, which, when many fish are captured, are fried and used for food by the natives. The fishermen suppose that the regular mode of bringing forth the young is through the mouth, but Mr. Boake satisfied himself that the fish produce their eggs in the ordinary way, and that after being deposited they are immediately taken into the mouth, either by the fish that has laid them or by another of the same species, where they are kept until they are hatched.

"The specimens given to me were two males and one female. The female had no ova in her mouth; but from the appearance of the abdomen it was evident that the ovaries were distended; and on opening into the cavity I found a large sac-like ovary on each side of the middle line. Each ovary measured 2½ inches in length and extended forward almost as far as the pectoral fin, where it formed a rounded free end, whilst posteriorly it was somewhat constricted, and opened by an orifice common to it and its fellow immediately behind the anus. The ovisac contained a very large number of eggs in various stages of growth. Some were like minute granules, others, and these were very numerous, like medium-sized shot, whilst a third set equaled in size grapes or small cherries and very materially exceeded therefore the size usually attained by the eggs of osseous fish. These last, only six in number in each ovary, had evidently almost reached the full period of intraovarian growth. Each ovum was attached to the inner wall of the ovisac by an independent pedicle, the atrophy of which would necessarily precede the discharge of the egg.

"The mouth and branchial chamber of one of the male fish were distended with 10 ova as large as those found in the ovarium, which were so closely packed together that water, or minute particles of food, could only pass backward to the gills or the œsophagus by filtering through the narrow interspaces between the eggs. In each ovum the development of the embryo had advanced so far that the eyes, chorda dorsalis, and cerebro-spinal nervous axis could without difficulty be distinguished, and from the ventral surface of the embryo numerous vessels were seen ramifying over the surface of the yelk. The embryos measured from one-half to seven-tenths of an inch in length. Only 1 of the 10 eggs had sustained any injury, its investing membrane being ruptured, so that a portion of its contents had escaped. It is interesting to note that the palatine teeth of the fish are granular, so that their form is well adapted for permitting the retention of the ova in the mouth with a minimum of injury.

"Mr. Boake's observations show that the eggs are not placed in the mouths of the fish by the natives for purposes of deception, but that the instinct of the animal prompts it to take them into that cavity; and it is, as these specimens show, by the male, and not by the female, that this act is performed. In this respect this Cingalese fish agrees with those already described by Drs. Wyman and Günther.

*London, 1864.

†Quarterly Journal of Science, p. 302, April, 1866.

"Opinions may differ as to the reason of this remarkable habit. It may be supposed that the male uses the eggs for food, or that he takes them into his mouth for temporary protection, discharging them again when the danger no longer exists, or that their presence in that cavity is connected with the process of incubation. The last of these suppositions seems to me most probable, for the habit of distending the mouth with eggs appears to be so common in this species of fish that it is a matter of ordinary observation amongst the natives. The eggs are not torn or bruised, as they would have been if subjected to the process of mastication, the stomach does not contain any fragments, and in each ovum is situated an embryo in a more or less advanced stage of development. Again, naturalists are acquainted with other fish which play a part in the incubation of their ova; the male pipe-fish, the male *Hippocampus*, and the *Aspredo lævis*, described by Wyman, possess special arrangements for receiving and carrying about the eggs until they are hatched. A close relation apparently exists between the number of eggs which come to maturity at a given time and the number which the male can carry in his mouth. In the female I examined, 12 eggs are evidently reaching their full growth, whilst the male has 10 in his mouth; and from another specimen examined by Mr. Boake as many as 13 were shaken out. This is a smaller number than was observed by Drs. Wyman and Günther in their Siluroids, but the eggs are in this species of much larger size. As the distended condition of the mouth would necessarily materially interfere with the reception of food by the male fish, it may be a question if he does not eject them during feeding, or perhaps during the time he plays the part of a dry nurse the quantity of food he takes may be almost *nil*."

It also appears that the Rev. Mr. Boake sent some of his specimens to F. Layard, esq., by whom they were submitted to Dr. Günther, who wrote concerning them:*

"A small collection of fresh-water fishes, made by the Rev. Bancroft Boake in Ceylon, and kindly submitted to my examination by F. Layard, esq., contained two Siluroid fishes of the genus *Arius*, which are of great interest, inasmuch as they prove that the peculiar habit which I have described in an American species, *A. fissus* (Fish, v, p. 173), viz, the mode in which the parent fish takes care of its progeny, is not confined to South American species, but exists also in the East Indian ones. The mature ova are of the same large size in all these fish, and in all it is the male which carries them in the spacious cavity of its mouth. According to Mr. Boake, who has published an account of the habits of these fish, they are called *Angaluwa*."

In Dr. Day's volume on the fishes of British India,† we find the following paragraph concerning this curious habit:

"The breeding of these fishes is peculiar and deserves attention. The eggs of *Arius* are large, averaging about 0.5 to 0.6 of an inch in diameter, and I have found many males of the genus, and also of *Osteogeniosus*, with from 15 to 20 eggs in their mouths. Some of these eggs were in an early stage of development, others nearly ready to be hatched; while in the mouth of one specimen was a hatched fry having the yolk bag still adherent. The eggs filled the cavity of the mouth and extended far back to the branchiæ.

"In the female organs of generation the eggs seemed to come to maturity in batches of perhaps 50 at a time. On examining the conformation of the ventral fins, those of the females appeared to be larger than those of the males; the rays were thickened by a deposit of fat, whilst the innermost one had a large pad attached to its posterior edge. These fins can be expanded into a cup-like surface, the use of which may be to receive the eggs as extruded, which may be vivified there by the male.

"Whether the male carries about these eggs in his mouth until hatched or only removes them when danger is imminent from some spot where he is guarding them is questionable, but in none of the specimens which I examined did I find a trace of food in the intestines of the males which had been engaged in this interesting occupation.

"This has been observed likewise elsewhere by Mr. Boake in Ceylon, and Dr. Hensel has recorded the same of a Brazil species, *A. commersonii;* Dr. Günther, of *Arius fissus* from Cayenne; and the same facts have been remarked in other Siluroid fishes."

As already stated, when Mr. Nelson examined the specimen which we have taken as the type of the species, he found 39 eggs in its mouth, many of which readily rolled out when he held the fish up by the tail. Unfortunately some of these eggs were lost and only four of them came into our possession.

* Description of a new Siluroid fish from Ceylon. <Ann. Mag. Nat. Hist., XVIII, third series, 1866, pp. 473 and 474.

† Fauna of British India, Fishes, vol. I, 1889, pp, 169–170.

The other specimen, which we have taken as the cotype, contained but one egg in its mouth when it came into our possession, and Mr. Nelson does not recall that any were lost from this fish. He saw 8 or 10 other examples of this cat-fish, but did not observe eggs in the mouth of any but the type specimen. According to his recollection, the eggs were quite uniform in size. The four which came into our possession measure, respectively, $\frac{10}{16}$ by $\frac{7}{16}$, $\frac{10}{16}$ by $\frac{11}{16}$, $\frac{10}{16}$ by $\frac{11}{16}$, and $\frac{11}{16}$ by $\frac{12}{16}$ of an inch.

The eggs are well developed, the embryo in each showing very distinctly. It lies wrapped around one side of the yolk sac, the head in every case being free. The maxillary barbel is well developed and very long, its length nearly equaling that of the head.

We have not been able to examine critically the single egg in the mouth of our second specimen, as it can not be removed without mutilating it or the fish owing, to the small size of the oral opening. Evidently this particular fish has not yet acquired what the Rev. Mr. Boake calls "the singular habit, when held up by the tail, of emitting from its mouth a quantity of eggs."

It will be noticed that the number of eggs (39) found by Mr. Nelson in the mouth of our type specimen is much greater than hitherto reported by any observer.

The suggestion by Dr. Wyman that the eggs are removed from the mouth when the cat-fish desires to feed is quite plausible, nay, imperative, if the fish ever feeds during the progress of the oral gestation. But it seems to us much more probable that the fish does not feed at all during the period of oral gestation, and begins to take food only when the young have developed sufficiently to leave the mouth. This is evidenced by the greatly constricted condition of the œsophagus, and comports more nearly with the habit of many other species of fishes during the spawning season.

Mr. Nelson informs us that these cat-fish are eaten by the natives, and that he himself regards them as the best fresh-water food-fish in Mexico.

It is proper in this connection to call attention to the method of reproduction in the sea cat-fish (*Galeichthys felis*). From information obtained in 1896 by Evermann and Bean, while studying the fishes of Indian River, Florida, they were convinced that this species is ovoviviparous. According to the testimony of competent observers among the Indian River fishermen and dealers, the adult females of this cat-fish are found filled with well-developed young in March, "each rolled up in a ball and the balls connected in a long string." While the technical description is a trifle faulty, the evidence points very strongly toward the ovoviviparity of the sea cat-fish.

6. Rhamdia wagneri (Günther).

The collection contains one specimen 11.5 inches long, from Teapa, and two others, 11.5 and 14.25 inches long, respectively, from Frontera. Head 4 to 4.5; depth 5 to 5.5; D. I. 6, A. 10; eye 7.5 to 8 in head, 3 in snout, high in head; snout 2.5; interorbital 2.5; barbels 6; mouth moderate, jaws equal; teeth in broad, cardiform bands on each jaw; maxillary barbel reaching adipose fin, but probably variable; mandibulary barbel to beyond base of pectoral, nearly twice as long as inner; head broad and flat, slightly longer than wide, covered with soft smooth skin; fontanelle in adult not continued behind eye; occipital process narrow, reaching about half way to dorsal spine; gillrakers 3 + 7 or 8; adipose fin 2.66 to 3 in body, reaching slightly farther than anal; caudal deeply divided, its lower lobe broad and rounded, upper smaller and pointed; body tapering backward from head, much compressed behind. General color, brown, lighter below, many dark dots over body; a dark lateral band; base of dorsal pale.

7. Pantosteus plebeius (Baird & Girard).

One specimen of this sucker, 5.75 inches long, was obtained by Mr. Nelson from the Rio Piedras Verdes, near Colonia Garcia, Chihuahua, and another 4.5 inches long by Messrs. Townsend and Barber from the Rio Casas Grandes near Old Casas Grandes, Chihuahua.

8. Campostoma ornatum Girard.

One specimen, 5.25 inches long, from near summit of the Sierra Madre Mountains in Chihuahua, near Colonia Garcia.

9. Leuciscus nigrescens (Girard).

One specimen 5 inches long from Rio Casas Grandes, one 5.25 inches long from near the summit of the Sierra Madre Mountains in Chihuahua, near Colonia Garcia, and one 5.75 inches long from Lake Santa Maria.

10. Notropis santamariæ, new species.

Type, No. 50002, U. S. N. M., a specimen 1.56 inches long, collected in September, 1899, by Mr. E. W. Nelson, from a small pool near Lake Santa Maria, Chihuahua, Mexico. Cotype, No. 964, U. S. F. C. reserve series, from same place.

Head 4; depth 2.65; eye 3.6; snout 4; maxillary 6; interorbital 6; scales 9–38–2, 13 pores; D. 8; A. 9. Body short, deep, and compressed; head short; snout short, obtuse; mouth rather small, oblique; jaws subequal, the lower slightly included; maxillary scarcely reaching eye; caudal peduncle moderate, its least depth 2.7 in head; scales large, loose, and closely imbricated, exposed portion of anterior ones deeper than long, 15 scales before origin of dorsal; lateral line greatly decurved and incomplete, only 11 to 13 pores; fins all small; origin of dorsal over base of ventrals, the longest dorsal ray about 1.4 in head; anal rather larger than dorsal; pectoral short, pointed, 1.25 in head, not reaching base of ventrals; ventrals barely reaching origin of anal; teeth apparently 4–4, slightly hooked.

Color in alcohol, olivaceous, paler below; back and upper part of side with numerous small dark specks, the edges of the scales dark; an obscure dark lateral band plainest on caudal peduncle; median line of back dark; top of head dark; snout somewhat dusky; dorsal and caudal dusky, other fins pale.

This species seems related to *N. frigidus,* from which it differs in the larger scales and the incomplete lateral line.

FIG. 2.—*Notropis santamariæ,* new species.

FIG. 3.—*Notropis lermæ,* new species.

11. Notropis lermæ, new species.

Type, No. 50003, U. S. N. M., a specimen, 2.5 inches long, collected August 9, 1901, by Dr. J. N. Rose, in Lake Lerma, near the town of Lerma, State of Mexico, Mexico; cotypes, 32 specimens, No. 50004, U. S. N. M.; 10 specimens, No. 977, U. S. F. C. reserve, and 10 specimens, No. 6762, Stanford University Museum—all from the type locality and collected under the same circumstances.

Head 3.7; depth 3.7; eye 5; snout 3.9; maxillary 3.3; mandible 3; interorbital 3; preorbital 6; D. 9; A. 8; scales 7–47–5, 23 scales before the dorsal; teeth 4–4. Body stout, deep, not greatly compressed, the back gently elevated, the anterior profile regularly curved from snout to origin of dorsal; head rather heavy; snout short and rather blunt; mouth small, oblique, the lower jaw included, the maxillary scarcely reaching eye; teeth small, hooked, somewhat crenate, the grinding surface not well developed;

caudal peduncle rather slender, not especially deep, the least depth being 2.5 in head; eye small; scales moderate, not closely imbricated, those before dorsal somewhat reduced in size; lateral line little decurved, not wholly complete, an occasional scale without any pore; fins all small; origin of dorsal much nearer base of caudal than eye, and behind insertion of ventrals, its rays about half length of head; anal short; pectoral very short, not nearly reaching ventrals, its length equal to height of dorsal fin; ventrals very short, not nearly reaching vent; caudal not deeply forked, the lobes about 1.5 in head.

Color in alcohol, grayish-olivaceous on back and upper part of side, the scales profusely covered with small dark punctulations; under parts paler; a broad dark median line from occiput to origin of dorsal, just in front of which it ends in a black blotch; a broad dark plumbeous band from humeral region along side to base of caudal fin, this band anteriorly somewhat above the axis of the body but following the axis posteriorly; dorsal, caudal, and pectoral fins dusky, the ventrals and anal pale.

This species seems most closely related to *Notropis aztecus* Woolman, from which it differs chiefly in the more slender caudal peduncle, the larger eye, less rounded snout, and the coloration.

The numerous cotypes show no appreciable differences.

The presence of fully developed eggs in one of the cotypes indicates that the spawning time of this species in Lake Lerma is in the late summer.

12. Notropis frigidus (Girard).

A single specimen, 2 inches long, from a pool near Lake Santa Maria, Chihuahua, seems to be this species, though too badly mutilated to enable us to identify it with certainty. The character of the teeth can not be made out and the scales are rubbed off so that they can not be accurately counted.

Head 4; depth 4.25; eye 3.5; snout 4; D. 7; A. 9; scales 5–35–6, 15 before the dorsal. Body slender, compressed; head small; mouth small, oblique, the lower jaw slightly included; scales thin, deciduous; fins small; origin of dorsal slightly behind base of ventrals. Color, pale yellowish or straw-color, a few dark punctulations along median line of back.

13. Agosia chrysogaster Girard.

One specimen, 3.25 inches long, of this interesting little minnow is in the collection made by Messrs. Townsend and Barber near the summit of the Sierra Madre, Chihuahua.

14. Symbranchus marmoratus Bloch.

One specimen, 12 inches long, from Cozumel Island, and two smaller ones, each 10.5 inches long, from Mujeres Island. Those from Mujeres Island were obtained by Mr. Goldman from the soft, slimy mud of a swampy, fresh-water pond about 2 miles from the southern end of the island. "This pond," Mr. Goldman says, "is 4 or 5 acres in extent and occupies a depression about a quarter of a mile from the open sea and only about 250 yards from the head of a salt-water lagoon, from which it is completely cut off, however, by a ridge 30 or 40 feet in height. The water in the pond is so shallow that it is everywhere filled with tall, growing, aquatic vegetation. There is a ranch close by, and to obtain water the people have dug holes at one end of the pond and walled them up with rocks to prevent their immediately refilling with soft mud. As it is, they gradually fill and have to be periodically cleaned. The only times the people ever see these eels are when these holes are cleaned. I happened to be there one day hunting birds and getting fish from the salt-water lagoon, and the people told me about the eels. After some difficulty I managed to persuade two men to undertake the job of cleaning the holes at once. They were hard to persuade, for they claimed they were apt to get fever from working in and overturning the mud. Many bushels of it were taken out and the eels found in cavities between the rocks. The people believe that the eels serve to purify the water. They assured me that no other fresh-water pond existed on the island."

Body very slender and eel-shaped, compressed posteriorly, the deepest part through base of head; head conic; tail very short, less than one-fourth total length; eye small, close to the end of snout; mouth horizontal, large; distance from tip of snout to angle of mouth contained three times in distance from tip of snout to posterior gill-opening; lips thin but long and overhanging; snout rounded, very short, equal to interorbital space; teeth small, those on jaws in a single row, except in the front of upper jaw where the rows from the sides join, forming a small patch; teeth on the palatines larger, conic, and in a patch anteriorly where the two rows join, a single row being on each side; gill-opening narrow, the width of the opening equaling distance between eyes; distance from vent to tip of tail 4.1 times in entire length; no fins except dorsal and anal, the latter extending from vent, the former beginning slightly in advance of this, both meeting at end of the narrowly pointed tail. Color in alcohol, dark olivaceous or brown, mottled with darker brown; under part of head and neck lighter.

15. Dorosoma cepedianum exile (Jordan & Gilbert). *Southern Hickory Shad.*

One specimen 12.5 inches long, from Montecristo. Head 4.66, 1.5 in last ray of dorsal; depth 2.75; eye 4.33; snout 5; maxillary 4; mandible 3; interorbital 3.5; D. 13; A. 31; scales about 75,–30; scutes 20 + 9. Body deep, compressed, the back elevated; dorsal median, slightly behind ventrals; caudal widely forked, the lobes equal. General color in alcohol, silvery, bluish above. This subspecies differs chiefly from the typical *cepedianum* in the considerably smaller scales.

16. Sardinella humeralis (Cuvier & Valenciennes). *Sardina Escamuda.*

Head 3.8; depth 3.25; eye 3; snout 3.5; D. 16; A. 18; scales 40; scutes about 27. Our specimens differ from current descriptions of this species in having an adipose eyelid; in the smaller eye, which is very slightly longer than snout; and in their greater depth. We can not, however, regard them as being any other species. Our two specimens, each 7.12 inches long, were taken from the crop of a brown pelican, at Puerto Morelos, April 1, 1901. Both are females, and their spawning time is in the spring, as evidenced by the mature eggs in each.

17. Fundulus grandis Baird & Girard.

Fifteen specimens, 5.2 to 6.8 inches long, from Progreso. Head 3; depth 4 to 4.3; eye 5.75 to 6; snout 3.3 to 3.7; mandible 2.4 to 2.5; interorbital 3; preorbital 9 to 10; D. 10 or 11; A. 9 or 10; scales 40 to 46,–14 or 15 The scales appear considerably smaller than in *F. heteroclitus*, the eye smaller, and the dorsal is more posterior.

18. Girardinichthys innominatus Bleeker.

Thirty-three specimens varying in length from 0.75 to 1.75 inches, all from Lake Lerma. Head, 3.7; depth 3.5; eye 3.5; snout 4.5; interorbital 2.5; D. 23; A. 26; scales 44,–16.

Body short, oblong, compressed; head compressed, thick, very steep; snout blunt; mandible directed vertically upward; premaxillaries greatly protractile; small cardiform or subconical teeth in each jaw in a single series, followed by a few small hooked teeth; mouth very small, nearly vertical; profile concave from orbit to nape, then slightly convex to dorsal fin; caudal slightly rounded; base of anal rather steep.

General color in alcohol, dusky gray, darker above, with many punctulations; a narrow dorsal band of dark from nape to dorsal fin; a dark, almost black, blotch on side above space between ventrals and vent, larger than eye; some specimens with many faint vertical broken dark bars on side of body, these usually obscure in the larger specimens.

This species is ovoviviparous. In several examples dissected, eggs were found in the ovary, each egg being surrounded by membranous tissue, which is attached to the sides of the ovary. Some of these young were very well developed; others are in a very immature state; while in others the eggs are very small. In one specimen were found 4 fully developed young showing the scales and fully developed fins, and in all respects resembling the parent, which was 1.2 inches long, while the young were nine-twentieths of an inch in length. In another specimen, 1.6 inches long, 24 young, two-tenths of an inch long, were found. These were immature, no scales being visible.

These specimens differ somewhat from current descriptions in several important particulars, viz the dorsal and anal rays are more numerous, the eye is larger, and the color is different, no mention being made by previous writers of the black blotch on the side. This spot is present in all our examples

So far as we have been able to learn attention has not previously been called to the viviparity of this little fish. Indeed, in Jordan and Evermann's Fishes of North and Middle America it is expressly stated to be oviparous. This opinion was probably simply an inference from the apparent fact that the anal fin of the male is not modified into an intromittent organ. No such modification is found in any of our 29 specimens, but we have not determined certainly that they are all females.

These fish, as well as those of all the other species obtained by Dr. Rose in Lake Lerma, are in many cases infested with some species of abdominal parasite—a tapeworm of some kind.

19. Cyprinodon eximius Girard.

The collection contains 44 specimens, all females, of this interesting little fish, obtained by Mr. Nelson from a pool near Lake Santa Maria, Chihuahua. They range in length from 1 to 1.5 inches.

Head 3 2; depth 2.5 to 3.2; eye 3.8; snout 3.8; interorbital 2.5 to 3; D. 9 or 10, length of longest ray about 2 in head, the anterior quite spine-like; A. 8 to 10, longest ray 1.8 in head. Body oblong, deepest in front of dorsal fin, compressed posteriorly; anterior profile evenly arched from base of dorsal fin to tip of snout; head large, deep, slightly compressed; eye high, distance from posterior edge

of opercle to eye equaling distance from tip of snout to posterior edge of pupil; upper jaw protractile; lower jaw prominent, very oblique, including upper jaw; a row of small villiform teeth on each jaw; dorsal outline dropping downward and backward along base of fin, thence backward and but slightly downward to base of caudal; caudal truncate; lower profile similar to dorsal, though not so greatly arched. Color in alcohol, dusky grayish, the central portion of each scale in some cases being dark olivaceous, making bands on each row of scales on side of body; belly and neck silvery white; 8 or 9 bands of dark about as wide as pupil, but irregular in width, on side of body; fins all dusky pale.

20. Belonesox belizanus Kner.

Three specimens, 4.2 to 5 inches long, from Progreso, Yucatan. Head 3 (2.75 to 3); depth about 6; eye 6 (5.5 to 6); snout 2.25; mandible 1.8 to 2; interorbital 3.8; scales 55 or 60,–16 or 17, about 6 rows on cheek; D. 8, the longest ray 3 in head; A. 10, the longest ray 2.8; ventrals 3.8; pectoral 2.8. Body very oblong, compressed posteriorly; head and anterior portion of body flat; head long, very flat above, the snout wedge-shaped; eye high; distance from tip of snout to anterior edge of eye equaling distance from center of pupil to posterior edge of opercle; upper surface of premaxillary plate not quite as long as postorbital part of head; upper jaw protractile, the premaxillaries forming together an elongate triangular plate, the bones separated by membrane; lower jaw long, projecting slightly beyond upper; mandibles formed similarly to premaxillaries; jaws arched, each with a broad band of cardiform teeth; dorsal placed far posteriorly; caudal rounded; anal in advance of dorsal, modified in the male into a long, slender intromittent organ. General color in alcohol, dark olivaceous, darker above; side with longitudinal series of dark spots, the spots on the posterior central portion of each scale; a dark spot, slightly larger than pupil, just above the central base of caudal; caudal dusky pale with numerous dark punctulations; other fins dusky pale.

21. Anableps dovii Gill. *"Quatro Ojos"; Four-eyed Fish.*

We have examined 2 specimens of this interesting fish, 7 and 8 inches long, respectively, collected by Mr. Nelson in the Tehuantepec River at Tehuantepec City. Head 4; depth 6.25; eye 4.5; snout 3.75; interorbital 4; width of mouth 2.5; dorsal 8; anal 8; scales, 67,–15; pectoral 1.5; ventral 2.3; anal 2.4; dorsal 2.4; middle caudal rays 1.4. Body long, much depressed on anterior half, posterior half somewhat compressed; head broad, very greatly depressed; mouth small, the maxillary and mandible short, the cleft not nearly reaching anterior border of eye; eye large, set very high, fully one-half being above the level of the low interorbital space; fins all small; dorsal posterior, its origin over tip of anal; caudal rather long, rounded; ventrals short, wide apart, not reaching vent; pectorals short, reaching only halfway to base of ventrals; scales small, smooth, and moderately firm.

Color in alcohol, brownish olive on back and upper part of side, pale below; median line of back with an obscure blackish band; a distinct black band from eye along middle of side to base of caudal peduncle, its lower boundary very distinct, in contrast with the paler color of lower side; a similar but paler dark line from above base of ventral to base of caudal, the pale yellowish line between these two scarcely equal to diameter of eye in width; in some cases this second dark line begins under tip of pectoral; dorsal and caudal dusky, other fins pale; tip of upper jaw dark; peritoneum black.

The unique structure of the eye of this curious fish merits a fuller description. Mr. M. C. Marsh, pathologist of the Commission, has made careful dissections of the eye of this species and kindly furnishes us the following notes:

The eye is crossed by a bar, like the diameter of a circle, and parallel with the length of the body. This bar is darker than the other external portions of the eyeball and has its edges darker still. Dividing the external aspect of the eye equally, it has its lower edge on the same level as the back of the fish, which is flat and straight from snout to dorsal, or nearly the whole length of the fish; so that when the body of the fish is just submerged the level of the water reaches to this bar, and the lower half of the eye is in water, the upper half in the air. Upon dissecting the eyeball from the orbit, it appears nearly round. A membranous sheath covers the external part and invests most of the ball. It may be peeled off, when the dark bar on the external portion of the eye is seen to be upon this membrane, which may correspond to the conjunctiva. The back portion of eyeball being cut off, one lens is found. The lining of the ball consists, in front, of one black layer, evidently choroid. Behind, there is a retinal layer. The choroid layer turns up anteriorly, making a free edge comparable to an iris. The free edge is chiefly evident in the lower part of the eye. A large pupil is left, but is divided by two flaps, continuations of the choroid coat, projecting from either side and overlapping. There are properly then two pupils, an upper and lower, separated by a band consisting of the two flaps, which may probably,

by moving upward and downward, increase or diminish the size of either pupil; an upward motion of the flaps increasing the lower pupil at the expense of the other, and vice versa. (Marsh).

This division of the pupil into two parts permits the fish, when swimming at the surface of the water, as is its usual custom, to see in the air with the upper portion and in the water with the lower. It is thus able to see not only such insects as are upon the surface of the water or flying in the air above, but also any that may be swimming beneath the surface.

According to Mr. Nelson the individuals of this species swim always at the surface and in little schools arranged in platoons or abreast. They always swim headed upstream against the current, and feed upon floating matter which the current brings them. A platoon may be seen in regular formation breasting the current, either making slight headway upstream or merely maintaining their station, and on the qui vive for any suitable food the current may bring. Now and then one may be seen to dart forward, seize a floating food particle, and then resume its place in the platoon. And thus they may be observed feeding for long periods. They are almost invariably found in running water well out in the stream, or at least where the current is strongest and where floating matter is most abundant, for it is upon floating matter that they seem chiefly to depend. They are not known to jump out of the water to catch insects flying in the air or resting upon vegetation above the water surface, nor do they seem to feed to any extent upon small crustaceans or other portions of the plankton beneath the surface.

When alarmed—and they are wary and very easily frightened—they escape by skipping or jumping over the water, 2 or 3 feet at a skip. They rise entirely out of the water, and at a considerable angle, the head pointing upward. In descending the tail strikes the water first and, apparently by a sculling motion, new impetus is acquired for another leap. This skipping may continue until the school is widely scattered. When a school has become scattered, and after the cause of their fright has disappeared, the individuals soon rejoin each other. First two will join each other and one by one the others will join them until the whole school is together again. Rarely do they attempt to dive or get beneath the surface; when they do they have great difficulty in keeping under and soon come to the surface again.

The air-bladder in an example 8 inches long was three-fourths of an inch long and nearly one-fourth inch in diameter. It was attached by a slender thread or duct three-fourths inch long to the under side of the stomach at the anterior end. The air-bladder lies immediately ventral to the stomach, its anterior end lying against and dorsal of the liver, in the tissues of which the duct is immersed.

No opening from the duct into the stomach could be found in the specimen dissected, though more careful dissection of a well-preserved or fresh specimen would probably reveal one.

The specimens obtained by Mr. Nelson were secured by means of a cast net in the Tehuantepec River at Tehuantepec City, which is situated about 50 miles from the sea at an altitude of 200 feet. The fish are so wild that it is very difficult to catch them. They jump over a seine readily and will not ordinarily take a hook. The cast net seems the most effective means for their capture.

This fish is viviparous, as is well known. The female (7 inches long) examined by us was collected in April, and contains nine young, each about 1.5 inches long. In each of these the yolk sac is quite large but flabby, as a result of the absorption of a considerable portion of its contents. In these little young the septum in the eye is quite evident and the color pattern of the adult is well shown. After the young are born Mr. Nelson observed that they remain for a time in quiet, protected water, not venturing into the strong currents until of considerable size.

Further down the Tehuantepec River near the coast the individuals of this fish are said to be larger than at Tehuantepec City. These fish are eaten by the natives, but are not often seen in market, on account of the difficulty in their capture.

22. Pœcilia butleri Jordan.

Three specimens, 1.37 to 1.67 inches long, obtained by Mr. Deam from a salt-water pool near the seashore at Salina Cruz, Gulf of Tehuantepec.

23. Mollienisia latipinna Le Sueur.

Nine males and 7 females from Progreso, all excellent specimens, in fine condition. The males range in length from 3.75 to 4.63 inches, and the females from 2.25 to 4 inches. Two females from Montecristo, 2.25 and 2.75 inches long; and one female from Mujeres Island, 2 inches long.

24. Tylosurus notatus (Poey). *Needle-fish; Long-jaws.*

One specimen, 13 inches long, from Progreso. Snout broken; measurements not accurate. D. I, 13; scales 85 before dorsal, about 45 from front of dorsal to caudal.

25. Tylosurus timucu (Walbaum). *Peixe Agulha; Timucu.*

One specimen, 20 inches long, from Teapa. Head 2.8; depth 11; eye 3 in postorbital part of head; A. 15; D. 16; about 135 scales before dorsal.

26. Hemiramphus brasiliensis (Linnæus). *Balao; Escribano.*

One specimen, 12 inches long, from Puerto Morelos. The following measurements are from end of upper jaw: Head 4.2; depth 5.75; eye 3.75; snout 3; interorbital 3.75; D. 14; A. 10; scales 54; pectoral 1.4 in head; ventrals 3.

27. Chirostoma humboldtianum (Cuvier & Valenciennes). *Pescado Blanco de Chalso.*

Five specimens, each about 5 inches long, from La Laguna, Jalisco, in the Sierra de Guanacatlan. Head 3; depth 4.75; eye 4.6; snout 3; maxillary 3; mandible 2.5; interobital 4; scales 53,–15; D. iv–13; A. 19; longest dorsal ray 2 in head; longest anal ray 2.2; pectoral 1.6; ventral 2.6; depth of caudal peduncle 3.3. Body slender, compressed; eye large, nearer tip of snout than posterior edge of opercle by a distance almost as great as diameter of orbit; interobital space flat, as is almost entire top of head; lower jaw projecting slightly, including the upper when closed; cleft of mouth horizontal, the edge of lower lip being on a line with center of pupil; lips thickened posteriorly, lower folding over upper at their union; maxillary nearly vertical, its distal end in advance of a vertical from anterior edge of orbit a distance equal to two-thirds diameter of pupil; minute teeth in small bands on jaws, none on vomer or palatines; gillrakers about 23, very slender, length of longest about equal to diameter of pupil; first two spines of dorsal about equal, the other two shorter; first few rays of soft dorsal highest, others gradually shortening; when the fin is elevated its edge is straight; caudal forked; anal similar to soft dorsal, except that its edge is slightly concave; ventrals reaching vent.

Color in alcohol, brownish-olive, darker above; a distinct dark lateral band, in which are small darker spots extending from upper part of base of pectoral to middle of base of caudal, becoming darker posteriorly; scales on upper part of body and sides edged with dark, sometimes with small dark dots; fins all dusky; dorsal, caudal, and pectoral with some dark.

28. Chirostoma promelas Jordan & Snyder.

One specimen, 8.5 inches long, from the Guadalajara market, caught in Laguna de Chapala, from which place the species was described. Head 3.3; depth 5; eye 6; snout 2.5; maxillary 3; mandible 2.25; interorbital 4.5; scales 53,–15; D. iv–11; longest dorsal ray 2.7 in head; A. 21; longest anal ray 2.5; pectoral 2; ventral 3.2; depth of caudal peduncle 3.8.

29. Chirostoma lucius Boulenger.

Two specimens, 8 inches long, from the Guadalajara market, caught in Laguna de Chapala, which is the type locality. Head 3.3; depth 5; eye 5.75; snout 2.6; maxillary 3; mandible 2.2; interorbital 4.2; scales 58,–15; D. v or vi–12; longest dorsal ray 2.4 in head; A. 20; longest anal ray 2.4; pectoral 1.7; ventral 2.8; depth of caudal peduncle 3.3.

30. Chirostoma bartoni Jordan & Evermann.

Forty-five specimens, ranging in length from 1.75 to 4.2 inches, all obtained by Dr. J. N. Rose in Lake Lerma, near the town of Lerma, State of Mexico. Until now, only the type of this species was known. A female, 3 inches long, gives the following measurements: Head 4; depth 5.5; eye 4; snout 3.5; maxillary 3.2; mandible 2.3; interorbital space, 3.2; D. iv–i, 10; A. i, 13; scales 41,–11, about 20 before the dorsal. Body slender, moderately compressed, the back rounded; mouth small; snout short; lower jaw but slightly projecting. Otherwise as in the type. The anal fin formula varies from i, 13 to i, 15; and the scales from 40,–10 to 42,–12.

31. Eslopsarum jordani (Woolman).

Among the specimens brought home from Mexico by Dr. Rose in 1901 is a package of small dried fish, which he purchased in the market at Yautepec, State of Morelos. These specimens range in length from less than one inch to 2.25 inches. They are thoroughly desiccated and difficult of identification, but seem to be the present species. Dr. Rose informs us that these little fish are sold in dishes containing a dozen or more and are eaten on toast or with meat. It is called "Charal de la Laguna" and is much relished.

32. Caranx hippos (Linnæus). *Horse Cravalla.*

One specimen, 13.5 inches long, from Montecristo. Head 3; depth 2.66; eye 4.66; snout 4; maxillary 2; mandible 1.8; interorbital 3.66; preorbital 5.5; D. vi–i, 20; A. ii–i, 17; scutes on lateral line about 26.

33. Caranx crysos (Mitchill). *Hard-tail; Runner.*

One specimen, 9 inches long, from Puerto Morelos. Head 3.5; depth 3; eye 3.5; snout 3; maxillary 2.5; mandible 2.2; interorbital 3.25; preorbital very narrow, about 16; D. VIII–I, 24; A. II–I, 19; pectoral one-eighth longer than head, 3 in body; longest dorsal ray 2 in head; about 48 scutes.

34. Trachinotus glaucus (Bloch). *Old-wife.*

One specimen, 10 inches long, from Puerto Morelos. Head 3.83; depth 2; eye 3.75; snout 4.5; maxillary 2.66; mandible 2.75; interorbital 2.75; preorbital very narrow; D. VI–I, 20; A. II–I, 17; longest dorsal ray 1.5 in body; longest anal ray 2.33; anterior rays of dorsal and anal greatly produced, reaching somewhat beyond middle of caudal.

35. Centropomus mexicanus Bocourt. *Mexican Robalo.*

One specimen, 12.5 inches long, from Montecristo. Head 3; depth 3.66; eye 5.75; snout 3.5; maxillary 2.66; mandible 1.75; interorbital 7; preorbital 13.5; scales 11–80–14; D. VIII–I, 10; A. III, 6; longest dorsal spine 2 in head, 1.5 in depth of body; longest anal spine 1.66 in head, 1.25 in depth of body; pectoral as long as ventral, 1.66 in head; ventral outline nearly straight; suborbital with 8 or 10 sharp retrorse teeth; preorbital with teeth at angle strongly serrated; opercular flap large, nearly reaching front of dorsal. General color in alcohol, dusky, silvery below, darker above; lateral line in a narrow black band; a dark blotch on middle of opercle, covering nearly half of it; faint indications of dark blotches over body above lateral line; dorsal membranes dark, other fins pale, except third anal spine, which is dark brown.

This fish is close to *C. parallelus*, but differs in that *C. mexicanus* has more teeth on the suborbital, those at the preopercle being fewer at the angle, larger and wider apart; those on the suprascapular are not so large, but there are 6 or 7, while in *C. parallelus* only 4 or 5 are found; scales larger in *C. mexicanus*, 5 or 6 fewer in lateral line, and 1 or 2 fewer between the lateral line and second dorsal.

36. Petrometopon cruentatus (Lacépède). *Coney; Red Hind.*

One specimen, 6.75 inches long, from Puerto Morelos. Head 2.8; depth 3.2; eye 5; snout 4.6; maxillary 2; mandible 1.75; interorbital 6.75; preorbital 10.5; D. IX, 14; A. III, 8; pectoral 1.6; ventrals 2; scales about 12–85–30. Body not so deep as in specimens heretofore described, nor is the supplemental maxillary so evident.

37. Lutianus griseus (Linnæus). *Gray Snapper.*

Five specimens, 8.25 to 9.5 inches long, from Mujeres Island, and one specimen, 3.5 inches long, from Cozumel Island. Head 2.7; depth 2.75 to 3; eye 4.3 to 5; snout 2.8 to 3; maxillary 2.5 to 2.8; mandible 2 to 2.3; interorbital 6 to 6.5; preorbital 6 to 6.5; D. X, 13 or 14; A. III, 8; scales 7–54–13, 7 rows on cheek; width of interorbital and preorbital usually equal; the fourth dorsal spine the longest, 2.75 to 3 in head; second and third anal spines about equal, the second the stouter, 3.3 to 3.67 in head; pectoral 1.5 to 2 in head; ventral 2 in head.

38. Hæmulon parra (Desmarest).

One specimen, 5.5 inches long, from Cozumel Island.

39. Pomadasis ramosus (Poey).

One specimen, 8.75 inches long, probably from Montecristo. Head 3.3; depth 3.5; eye 4.3; snout 3; maxillary 3.5; mandible 3.5; interorbital 4; preorbital 6; scales 6–55–12; D. XIII, 12; longest dorsal spine 1.8 in head; A. III, 7; longest spine 1.5 in head; pectoral and ventral each 1.5 in head.

40. Orthopristis chrysopterus (Linnæus). *Pig-fish.*

Two specimens, 9.75 and 10 inches long, from Progreso. Head 3; depth 2.8; eye 5.5; snout 2.25; maxillary 3.3; mandible 3; interorbital 4.67; preorbital 3.6; pectoral 1.5 in head; D. XII, 16 or 17; A. III, 11 or 12; scales 10–65–17. Longest dorsal spine 3 in head; second anal 6 in head; base of soft dorsal 1.5 in spinous dorsal; highest dorsal spine 3 in head; pectoral not reaching past tips of ventrals.

41. Xystæma cinereum (Walbaum). *Mojarra Blanca.*

Two specimens, each 8.5 inches long, from Mujeres Island, and one small example from Cozumel Island. Head 3.3; depth 2.75; eye 3.25; snout 3.25; maxillary 2.8; mandible 2; interorbital 3; scales 6–45–10; D. IX, 11; A. III, 6; second dorsal spine longest, 1.8 in head; second anal spine longest, 2.5 in head; ventral short, not reaching vent, 1.66 in head; pectoral fin slightly longer than head; caudal deeply forked, lobes longer than head, scaled; dorsal and anal fins, when depressed, entirely concealed in a scaly sheath.

42. Gerres mexicanus Steindachner. *Mexican Mojarra.*

The collection contains four specimens of this rare species, all from Teapa, which is the type locality. They range in length from 5.75 to 10 inches. Head 3.3; depth 2.5; eye 3 in small specimens, 3.5 to 3.67 in larger ones; snout 3.25 to 3.67; scales 6–46 to 50–10 or 11; D. IX, 10 or 11; A. III, 8 or 9. Body compressed, rhomboidal in form, covered with large smooth scales; back much elevated; lateral line continuous, concurrent with the elevated back, beginning on a line with upper margin of eye; head flat, a slight depression above the eye; mouth moderate, upper jaw very protractile; maxillary extending to about middle of eye, its length about 2.5 in head, exposed portion oblong, width 2 in length; preorbital and preopercle serrate; premaxillary groove entirely free from scales; second dorsal spine strong and long, head contained in it 1.3 times; second anal spine stronger but shorter than second dorsal, 1.67 in second dorsal; outer edge of dorsal fin forming a deep reentrant angle; anal same shape as dorsal but smaller; pectoral reaching beyond tips of ventrals in large specimens, not so far in small ones, its length equaling head.

General color, bluish-silvery above, silvery below; very distinct dark longitudinal lines along the middle of each row of scales; dorsal, caudal, and anal fins dusky; the margin of dorsal black; a dark supraorbital spot; pectoral and ventral pale.

43. Menticirrhus littoralis (Holbrook). *Surf Whiting.*

One specimen, 11.75 inches long, from Progreso. Head 4.5; depth 4.5; eye 7.3; snout 3.25; interorbital 4.75; D. X–I, 24; A. I, 7; scales 8–60–16. This fish has not heretofore been recorded south of Texas. It is worth noting that the more southern specimens have smaller scales, as noted in another member of the same family, *Aplodinotus grunniens*, found at Montecristo.

FIG. 4.—*Aplodinotus grunniens* Rafinesque.

44. Aplodinotus grunniens Rafinesque. *Fresh-water Drum; Gaspergou.*

One specimen, 13 inches long, from the Rio Usumacinta at Montecristo. Head 3.5; depth 3.2; eye 4.67; snout 4; maxillary 2.75; mandible 2.5; interorbital 3.5; preorbital 6.5; scales 9–60–12, counted from vent to lateral line, and from first dorsal spine to and including lateral line; D. X, 31; A. II, 7; longest dorsal spine 2.16 in head; longest anal spine 1.67 in head; pectoral 1 in head. Body oblong; back much elevated and compressed; profile long, steep, and straight; head slightly compressed; mouth moderate, subinferior, low; maxillary reaching middle of eye; teeth in villiform bands, outer scarcely enlarged; lower pharyngeals completely united; gillrakers short, thickish, 6+14; preopercle serrated; snout bluntish; dorsal spines strong and high, a scaly sheath at base of spines, the two dorsals connected; caudal doubly truncate; second anal spine unusually large and strong; scales rather thin and deep, the series somewhat oblique, crowded anteriorly.

Color in alcohol, grayish-silvery, dusky above, with indications of two or three darker bands over shoulder; a dark blotch on opercle; dorsal and caudal same as body, the upper half of membrane darker, other fins pale. This fish differs from more northern specimens in the long, narrow, falcate pectoral fin.

The finding of this species so far south is a very interesting discovery. Though a fish of wide distribution, occurring throughout the Great Lakes region and southward in the larger streams of the Mississippi Valley and Texas, it has not hitherto been noted from any point south of Matamoras near the mouth of the Rio Grande, from which place Girard, in 1859, described it as a new species under the name *Ambiodon neglectus*. It was obtained by Drs. Jordan and Gilbert in the Red River at Fulton, Ark., and the Colorado River at Austin, and the senior writer of this paper has seen, in the Houston market, numerous examples from near the mouth of the Trinity River, Texas. He has also recorded it from the Neches and Angelina rivers in eastern Texas, and from Lakes Tasse and Peigneur, Louisiana. The Rio Usumacinta is about 600 miles south and 300 miles east of the mouth of the Rio Grande.

45. Petenia splendida Günther.

The collections contain 3 specimens of this fish from Montecristo and 1 from Frontera. Head 2.87; depth 2.6; eye 5.3; snout 2.8; interorbital 4; maxillary 1.8; mandible 1.5; D. xv, 13; A. v, 10; scales 6–38–12, 8 vertical or 6 horizontal rows on cheek; longest dorsal spine about 3 in head; longest dorsal ray about 1.8; last anal spine 2.75; longest anal ray nearly 2; pectoral 1.5; ventrals 1.6.

FIG. 5.—*Petenia splendida* Günther.

Body stout, greatly compressed; dorsal outline strongly arched; snout long and pointed; eye large, high up; mouth large, lower jaw projecting; maxillary long, clavate, reaching much beyond eye; preorbital very narrow; caudal peduncle much compressed, width 2.5 in least depth; form and general appearance very much resembling the crappie (*Pomoxis annularis*); dorsal and anal fins large, tips of the rays reaching beyond base of caudal; ventrals long and pointed, their tips reaching base of anal.

Color, silvery on side, darker above, body everywhere with numerous small black specks, these especially plain on side of head and humeral region, the dark on rest of body taking the form of dark borders on the scales; middle of side, especially in younger individuals, with 6 or 7 dark vertical blotches appearing as half bars extending from median line of back to below middle of side; the first of these rather as a dark blotch on upper part of opercle; base of caudal with a large round black spot, more or less definitely surrounded by a white border, the white in most specimens as a distinct white border, but in others breaking up and penetrating the black spot; dorsal, anal, and caudal with numerous small round black spots, plainest and most numerous on the soft dorsal, and arranged more or less definitely in rows extending downward and backward; pectoral pale; ventrals somewhat dusky.

The above description is based chiefly upon the largest specimen, which is from Montecristo.

46. Cichlasoma teapæ, new species.

Type, No. 50005, U.S.N.M., a mature male 9.5 inches long, collected April 1, 1900, by E. W. Nelson and E. A. Goldman, in the Rio Teapa, at Teapa, Tabasco, Mexico. Cotype, No. 976, U.S.F.C. reserve, a well preserved specimen, 8 inches long, collected at the same time and place.

Head 3.75; depth 2.6; eye 5; snout 2; maxillary 4.5; mandible 3.5; interorbital 2.6; preorbital 3.2; D. xvii, 13; longest dorsal spine 2.3 in head, ray 1.2; A. vi, 9, longest anal spine 2.2, ray 1.25; pectoral 1.5; ventrals 1.2; caudal 1.5; scales 6–33–12, 5 rows on cheek. Body comparatively slender, compressed; caudal peduncle much compressed, its least width 3 in its least depth; head short, compressed, its anterior profile ascending very abruptly from the short, blunt snout; a high nuchal crest or hump, highest above eyes, the anterior profile thus made concave in front of eyes; snout short, anterior profile ascending abruptly; mouth small, nearly horizontal; jaws subequal, or the lower slightly included; teeth strong, canine-like, tips brown; eye rather small, entirely above tip of snout; dorsal fin beginning over base of pectoral, the spines rather slender and weak; soft rays of dorsal long, reaching base of caudal; anal spines stronger than those of dorsal, the rays somewhat longer; caudal fin truncate; pectoral rather broad, not reaching tips of ventrals; ventrals long and

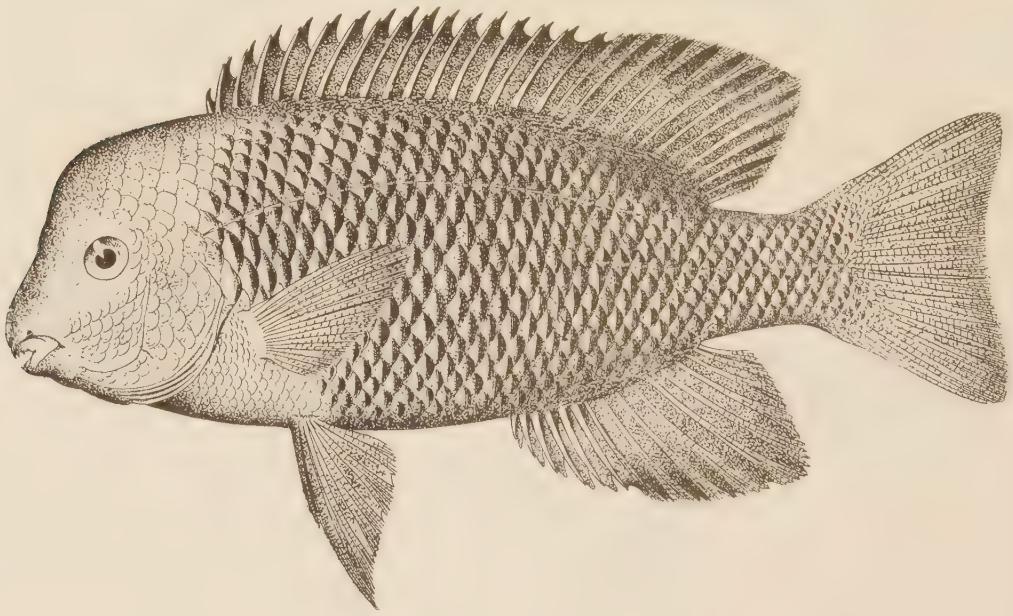


Fig. 6.—*Cichlasoma teapæ*, new species.

pointed, extending slightly beyond vent in type, not quite reaching it in cotype; tips of dorsal and anal extending slightly beyond base of caudal.

Color in alcohol, dusky white, paler on belly, the outer half of exposed portion of each scale brownish black, the distinction between this and the pale base of the scale being very marked; traces of four or five dark vertical blotches on side under dorsal fin and one at base of tail; trace of black blotch under and above tip of pectoral; entire head pale brownish; dorsal, anal, and caudal brownish, apparently without spots; pectoral and ventrals pale.

This species is related to *C. melanurus*, but differs from it in the more slender body and very different coloration. It also resembles *Heros gibbiceps* Steindachner, the type of which also came from Teapa, in the strong development of the nuchal crest. From that species it differs in the presence of a frenum on lower jaw, which makes it a true *Cichlasoma*, and in the different coloration.

47. Cichlasoma parma (Günther).

One specimen, 9 inches long, from Frontera, and one 4.13 inches long, from Montecristo. Head 3; depth 2; eye 4.75; snout 2.17; preorbital 3.75; interorbital 2.6; maxillary 3.5; mandible 2.4; D. xvii, 11; A. vi, 8; scales 6-30-12, 6 rows on cheek; longest dorsal spine 2, ray 1.1; longest anal spine 2,

ray 1.2; pectoral 1.4; ventral 1.1; caudal 1.25. Body oblong-ovate, much compressed; dorsal profile strongly and regularly arched, slightly concave between anterior part of eyes; snout moderate; mouth moderate, jaws subequal, maxillary not nearly reaching eye; teeth in front of jaws strong, canine-like, somewhat recurved, tips brown; caudal peduncle much compressed, least width 2.5 in least depth; fins large; soft lobes of dorsal and anal reaching past middle of caudal; pectoral broad, scarcely reaching vent; ventrals pointed, reaching base of anal.

Color, pale brownish, side with several more or less indistinct diffuse black blotches; a more or less ocellate black spot at base of caudal; pectoral pale, other fins dusky, the soft dorsal, anal and caudal with numerous obscure small black spots.

This species resembles *C. melanurus*, but seems to differ in the somewhat deeper body, longer snout, and more spotted coloration on the caudal and soft dorsal and anal.

48. Cichlasoma melanurus (Günther).

Four specimens, each about 8 inches long, 3 from Montecristo and 1 from Teapa. Head 3; depth 2.2; eye 4.5; snout 2.4; preorbital 3.5; interorbital 2.75; premaxillary 4; mandible 2.75; D. xvii, 11; A. vi, 8; scales 6–33–12, 5 rows on cheek; longest dorsal spine about 2, ray 1.17; last anal spine 2.17, ray 1.2; pectoral 1.4; ventral 1, caudal 1. Body rather oblong, compressed, the back considerably elevated; snout short; anterior profile more or less concave, depending upon the development of the fatty nuchal hump; eye entirely above level of upper lip; mouth small, slightly oblique, jaws subequal; anterior teeth in jaws moderate-sized canines, brown at tip.

Color, dirty white, marbled and blotched with darker, the dark tending to gather in irregular vertical bars; a more or less distinct ocellated black spot at base of caudal, this sometimes obscure; pectoral pale, other fins more or less dusky; soft dorsal and anal black at base, the outer part pale.

This species resembles *C. parma*, but seems to differ from it in the more slender body, the shorter snout, the more abrupt anterior profile and in the coloration.

49. Heros affinis Günther.

One specimen, 3.4 inches long, from Progreso.

50. Heros cyanoguttatus (Baird & Girard).

One example, 8 inches long, from Montecristo. Head 3.2; depth 2; eye 4; snout 2; preorbital 3; interorbital 2.3; maxillary 3.5; mandible 2.75; D. xvi, 11; A. vi, 9; scales 6–30–11, 6 rows on cheek; longest dorsal spine 2.2, ray a little longer than head; last anal spine 2.25, ray 1.2; pectoral 1.2; ventral 1; caudal 1. Body short and deep; head very short, anterior profile very high, gently curved from tip of snout to origin of dorsal; eye very high; mouth low, small, nearly horizontal; teeth rather small, canine-like in front of jaws, tips slightly brown; soft dorsal and anal extending to or beyond middle of caudal. Color in alcohol, dirty white, blotched and spotted with black, the black most evident below lateral line; outer half of many of the scales black; middle of side with numerous small, irregular wavy lines and roundish pale spots, these probably blue in life; pectoral pale; the other fins dusky or even black, the ventrals and anal blackest.

This species has not hitherto been reported from southern Mexico.

51. Heros urophthalmus Günther.

Head 2.9; depth 2; eye 4.3 (4 to 4.5); snout 2.6 (2.5 to 3); maxillary 2.67; mandible 2.25; interorbital 3; preorbital 4; D. xvi, 10; A. vi, 7 (v to vii, 6 to 8); scales 5–29–10, 5 rows on cheek; longest dorsal spine 2.25, ray 1.25; last anal spine 2.25, ray 1.4; caudal 1.4; pectoral 1.25; ventral 1.25. Body short and robust, compressed, the caudal peduncle deep and narrow; back considerably elevated, anterior profile concave between the eyes; no nuchal crest on any of the specimens examined; head large, snout rather long; mouth rather large, somewhat oblique; maxillary reaching orbit; jaws equal; teeth conic, the tips brown; scales large, smooth, lateral line complete, but dropping three rows under middle of soft dorsal; fins all well developed; pectoral rather long, nearly reaching origin of anal; ventral reaching past vent; soft portion of anal and dorsal reaching middle of caudal.

Color, dark or brownish, with 7 broad black vertical crossbars, the first extending from in front of dorsal fin to upper end of gill-opening, the second from under front of dorsal to base of pectoral, the third and fourth from spinous dorsal to belly between ventrals and anal, the fifth from front of soft dorsal to front of soft anal, the sixth across base of caudal peduncle, the seventh across middle of caudal peduncle; a large ocellated black spot at base of caudal fin; pectoral pale, all other fins dark, sometimes almost black, probably bluish in life.

This species is well represented in the collection, there being 7 specimens 7 to 8 inches long from Mujeres Island, 7 specimens 8 to 9.5 inches long from Montecristo, 7 specimens 6.75 to 8.25 inches long from Chichen Itza, and 3 specimens 3.5 to 4 inches long from Progreso. It is easy to distinguish the specimens from any of these localities. Those from the salt or brackish waters at Mujeres Island are shorter, plumper, and decidedly darker than those from either of the other localities; the black bars are very distinct, as is also the caudal ocellus. The specimens from Montecristo are more slender and the color very much paler; the black vertical bars are in each case quite indistinct, in some instances being almost or quite lost. The black caudal spot is less black and the white border more evident. The 7 specimens from the cenote at Chichen Itza are intermediate in color between those from the two other places, and are considerably more slender. They have an emaciated, starved appearance, which is doubtless accounted for by the fact that they had been caught from the cenote and kept in a trough or small artificial inclosure, presumably without sufficient food, for some time previous to coming into Mr. Nelson's possession.

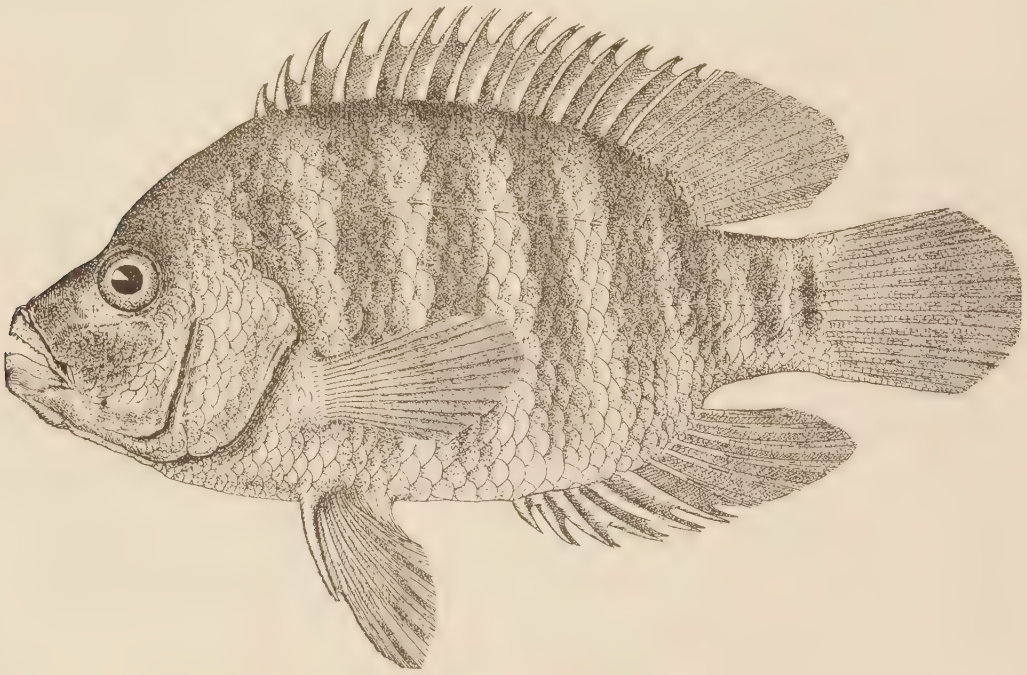


FIG. 7.—*Heros urophthalmus* Günther.

Although it is easy to pick out the individual fish from any one of these localities, we do not find any structural differences of value. The color differences are due simply to the character of the water in which they were found. The difference in form is simply a question of food supply. Had all received the same food or in the same amount, these differences probably would not have appeared.

52. Spheroides marmoratus (Ranzani). *Swell-fish.*

One specimen, 10.75 inches long, from Cozumel Island.

53. Spheroides testudineus (Linnæus). *Swell-fish; Puffer.*

One specimen, 9 inches long, from Mujeres Island. Head 3; eye 8; snout 2; interorbital 2.5 in head, 1.3 in snout; D. 8; A. 6. No cirri, no prickles, but many pores over most of anterior half of body.

54. Philypnus dormitor (Lacépède). *Guavina.*

Two specimens, 6 and 10.5 inches long, from Teapa. Head 3.6; depth 6.6; eye 7.5; snout 3.25; maxillary 2.33; interorbital 4.87; preorbital 7.5; D. VI, 10 or 11; A. I, 8; scales about 60,–22.

55. Dormitator maculatus (Bloch). *Mapiro.*

Four small specimens, 1.7 to 2.3 inches long, collected December 25, 1898, by Mr. C. C. Deam from a salt-water pool at Salina Cruz.

56. Batrachoides goldmani, new species.

Type, No. 50006, U. S. N. M., a specimen 10.5 inches long, collected May 7, 1900, by E. W. Nelson and E. A. Goldman, in the Rio Usumacinta, at Montecristo, Tabasco, Mexico.

Head 2.75; depth 5; eye 9; snout 4.25; D. III, 24; A. 18. Body fusiform; head very broad, much depressed; caudal peduncle slender, much compressed; mouth large, lower jaw strongly projecting; maxillary reaching far beyond eye; teeth small, those on vomer in two irregular rows, about 26 in number, the inner the larger; palatine teeth about 15 on each side, irregular in size and position; teeth of lower jaw in 2 large patches in front, the outer somewhat enlarged; eye small; dermal fold on side of occiput obscure; dermal filaments on jaws and sides of head rather small; opercle with 2 rather strong

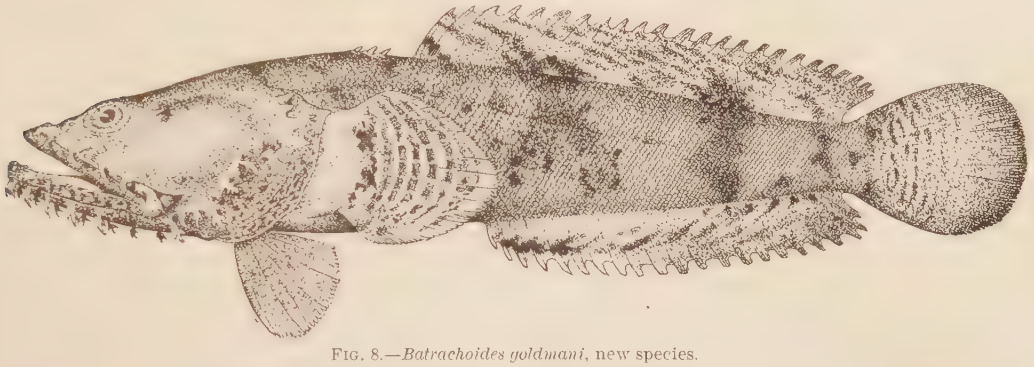


FIG. 8.—*Batrachoides goldmani*, new species.

divergent spines, but covered by skin; subopercle with 2 similar stronger spines; dorsal spines short and blunt; soft dorsal long, about half length of body; anal base 2.5 in length; caudal rounded; pectoral moderate, 1.67 in head; ventrals short, 2 in pectoral.

Color, grayish, with 4 irregular dark cross-blotches, the first under base of pectoral and involving the 3 free spines; the second under first one-third of dorsal and extending upon it; the third under last one-third of dorsal and likewise extending upon it; the fourth, a dark bar at base of caudal; top of head and back olivaceous or dusky, blotched irregularly with dark; under parts of head paler, with dusky and violet markings; spinous dorsal dark; soft dorsal violet or rusty with 2 large black blotches on base; a smaller one between them, the fin crossed by irregular short dark and pale lines; anal similar to soft dorsal; caudal dark, irregularly barred at the base; pectoral dark at base, the rest of fin with irregular bars of white and brownish; axil pale; ventrals somewhat dusky.

This species differs from *B. surinamensis* in several important particulars, but chiefly in the smaller size of the anal and dorsal fins. In *B. surinamensis* the anal has 26 rays and its base is nearly half the length of the fish, and the dorsal has 29 rays, the base being more than half length of body.

Contributions from the Biological Laboratory of the U. S. Fish Commission,
Woods Hole, Massachusetts.

THE REPRODUCTIVE PERIOD IN THE LOBSTER

By FRANCIS H. HERRICK.

Whenever it is impracticable to determine the reproductive periods in an animal by watching its behavior, the structure of the ovary will usually furnish a clew. This is true of the crustacea, and probably of all other animals. My present aim is not only to illustrate this fact, but to settle certain questions concerning the breeding habits of the American lobster about which doubt is still expressed. To state the question briefly: How often does the adult animal lay eggs?—Every year, once in two years, or at longer intervals, for these diverse answers have been given by various writers.

Over ten years ago I found that a study of the comparative anatomy of the ovaries taken at different seasons seemed to prove the impossibility of annual spawning,* and to demonstrate that eggs were not laid oftener, as a rule, than every other year. This was further illustrated in a fuller work published in 1895.† While confident that these conclusions were reliable, the main evidence in their support was indirect, as I took pains to state at that time. It is now possible to supplement these earlier observations by direct experiments upon living animals, and the theory of biennial spawning is supported by a variety of testimony. The true answer to the question, How often does the mature lobster lay her eggs? is, therefore, Once in two years, as a rule.

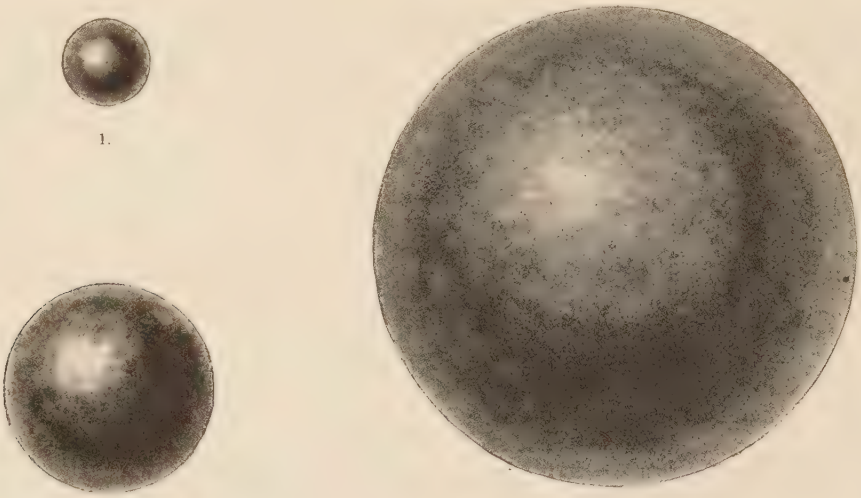
We will now consider the evidence upon which this conclusion is based. Apart from the question of the frequency of spawning, the following facts are known: (1) The majority of the egg-producers for any given year lay at a definite season—namely, in summer. The breeding or egg-laying season at Woods Hole, Massachusetts, reaches its height during the latter part of July. (2) Following ovulation comes a long period of fosterage, inaccurately called incubation, which lasts from ten to eleven months, during which the eggs are carried under the "tail" or abdomen. (3) The hatching of this generation of external eggs follows in May or June.

To revert now to the question of the frequency of spawning. Do the berried females whose young hatch in May, 1902, lay again in July of that year, or not until July, 1903, or in some subsequent year?

In 1895 I recommended that the direct experiment should be tried of keeping female lobsters alive from the period of the hatching of their last broods until the

* Notes on the Habits and Larval Stages of the American Lobster, Johns Hopkins University Bulletin, No. 88, May 1891.
† The American Lobster; A Study of its Habits and Development. U. S. Fish Commission, Washington, 1895.

laying of the next generation of eggs, which upon the theory of biennial spawning would be due in one year.* Through the courtesy of the United States Fish Commission this experiment was made in 1900–1901. On June 19, 1900, Mr. Vinal Edwards placed in a floating car thirty-six lobsters from which the old external eggs had been removed, fed them regularly, and on the first of each month following caught one of the animals and preserved its ovaries. When the last survivor was taken, May 1, 1901, just ten months and twelve days from the beginning of the experiment, not one of the animals had laid eggs. Further, an examination of the ovaries disclosed no evidence of absorption of the ova or abnormal retardation of their growth, such as we might look for upon the theory of annual spawning—nothing in fact but a slow, regular growth of the organs.



1. 2. 3.

FIG. 1.—Initial stage of ovarian egg shortly after egg-laying in the lobster. Radius, 5.7 mm.; contents, 0.77 c. c. Animal taken 36 to 48 hours after egg-laying, July 29.

FIG. 2.—Ovarian egg in intermediate stage, one year after egg-laying. Radius, 14.1 mm.; contents, 11.71 c. c.; average of ten ova from animal taken June 19, and ten ova taken June 28.

FIG. 3.—Ovarian egg in final stage, when ready to be laid. Radius, 32 mm.; contents, 136.97 c. c.; average of five unextruded ova from the oviduct of a lobster which had recently laid eggs, August 17.

The testimony which is plainly borne by the structure of the ovaries of these animals is of much importance, and will be briefly analyzed.

In a single generation of ovarian eggs three stages are entitled to special consideration: (1) The initial stage, when the ova of the preceding generation are laid; (2) the intermediate stage, when these eggs are hatched; and (3) the final stage, when the ovarian eggs have reached their full size and are ready to be expelled from the body. (Figs. 1–3.)† The time interval between stages 1 and 2 is known to be approximately one year, being measured by the development of the external eggs

*Ibid, p. 72.

†All the figures in this paper are drawn to the same scale, with an enlargement of 40 diameters. Unless otherwise stated, the size of each egg figured represents an average of ten of the larger peripheral ova from the ovary of the same individual, all being subjected to the same treatment. The eggs were rolled under slips of glass and then outlined with the camera, the measurements being made from the sketches thus obtained. Several measurements of each egg were required, owing to the distortion which arises from mutual pressure in the ovary.

which serve as a handy and convenient chronometer. The ratio of growth in stages 1 and 2 can also be determined. The volume of the laid egg in the final stage is also known, so that it only remains to ascertain the time interval between stages 2 and 3.

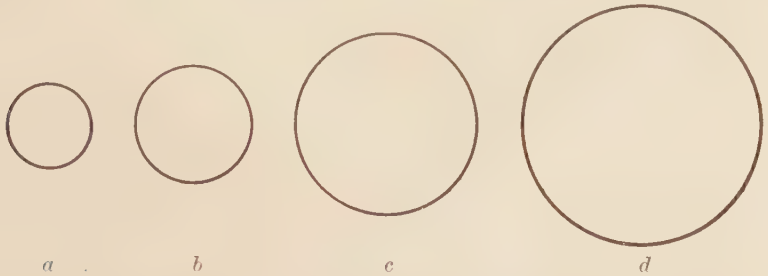


FIG. 4.—Series to illustrate the growth of the ovarian eggs during first year after spawning. (*a*) Ovarian egg in initial stage as shown in Fig. 1. (*b*) Ovarian egg fifteen days after egg-laying. External eggs borne on the swimmerets, in "nauplius" stage. Radius, 8.6 mm.; contents, 2.67 c. c., August 6. (*c*) Ovarian egg forty-two days after egg extrusion, the age being determined by state of development of attached ova. R. 12; contents, 7.22 c. c., August 21. (*d*) Ovarian egg, after approximately one year from egg-laying, average of ten ova from lobster taken June 19, 1900, with external egg ready to hatch. R. 16.2; contents, 17.77 c. c.

The relative volumes of the ovarian eggs at these successive periods are as follows: 0.77 c. c., 11.71 c. c., 136.97 c. c. Accordingly, during the first period of growth the ova increase in volume fifteen times, or the ratio of growth may be expressed by 1 : 15. Upon the theory of biennial spawning we should expect the ratio of growth for the second period to be approximately the same. The values

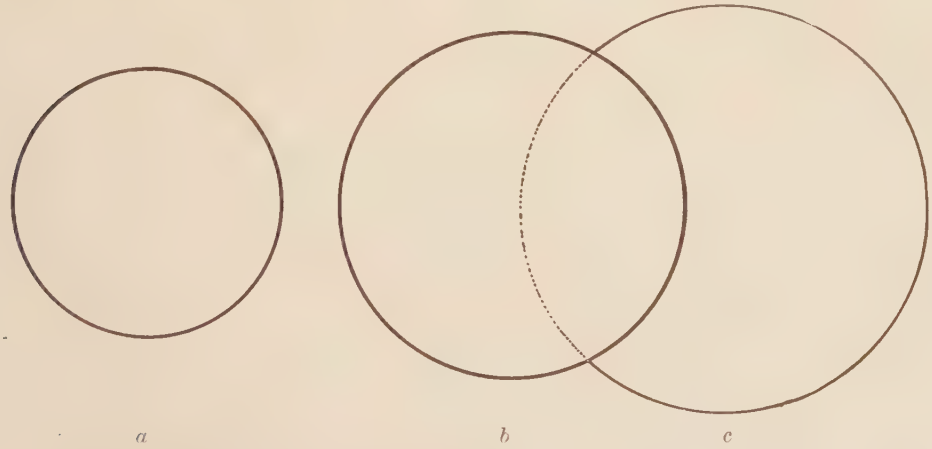


FIG. 5.—Series illustrating the growth of the ovarian eggs during the second year after spawning. (*a*) Ovarian egg one year ten months after egg-laying. The female from which this ovary was taken was kept in a floating car from June 19, 1900 (period of hatching), until May 1, 1901. Radius 17.9; contents, 23.97. (*b*) Average size of two fresh ova, taken August 19. These eggs were soon to be laid as shown by their size, color, and general appearance of ovary. (*c*) Unextruded ovarian eggs, taken about three days after egg-laying. The external eggs were in segmentation. Radius, 27.1; contents, 83.19 c. c.

given above, for which only a relative degree of accuracy can be maintained, give this ratio as 1 : 12. This result supports the conclusion that the ovarian ova which in spring following the last ovulation attain the size shown in fig. 2, experience a second period of rapid growth and are laid during the following summer. This is rendered

all the more certain from the characteristic appearance of the ovaries of certain lobsters taken in summer in the very midst of the spawning season. There are certain infallible signs which prove that the ovarian eggs are due in the current season, the most conspicuous of which is the color change. From a light pea-green the ovary becomes a dark olive or rather a greenish-black color, which is often noticeable at the very beginning of the period of rapid growth, or at least when many of the ova are scarcely more than $\frac{1}{2}$ mm. in diameter (see fig. 5, *a*), and not due for some weeks. Then with the further growth of the ova the transparent elastic wall of the ovary becomes distended and assumes a beaded appearance. As the period of ovulation approaches, the ovarian eggs become free, and, if the wall is cut, flow out in a stream. It is thus evident that during the second year the ovary undergoes little change with respect to the size of the ova up to the beginning of summer or of the second period of rapid growth. Further direct observations upon lobsters kept alive for upwards of ten months after the hatching of a brood demonstrate that their ovarian eggs attain that size which the theory of biennial spawning demands.

Accordingly, a very slight change from the condition shown in stage 2 ushers in a second period of rapid growth, and this period, beginning usually sometime in June or early July, is brought to a close in the course of a few weeks, when the new generation of eggs is extruded.

The rapidity of growth of the ovarian eggs for a period of six weeks, as measured from the initial stage by means of the chronometer provided by the eggs attached to the swimmerets, is illustrated by figures 4 and 5. The egg more than doubles in volume during the first fortnight, while in seven weeks the initial volume has been increased 9.3 times.

While we speak of "stages" and "periods of growth" as a matter of convenience, it is hardly necessary to be reminded that every change is gradual, and that no abrupt transitions are known.

The theory of biennial spawning is supported: (1) By the statistics of the fishery; (2) by the anatomy of the ovary of the adult female taken at different seasons; (3) by the ratio of growth of a given generation of ovarian ova for stated periods; (4) by observation on animals kept alive for long periods; (5) by the evidence of the rapid growth of ovarian eggs of spawners for any given year during the height of the breeding season.

It is to be expected that the rule to which the majority conforms has many exceptions in individual cases, for variation is the rule of life. It seems quite probable that occasionally a lobster may lay eggs in two consecutive seasons, and that in other cases the normal biennial period may be even prolonged, but I have nothing to offer under this head.

I have shown in an earlier work* that a considerable number of spawners laid their eggs out of season, as in the fall and winter months. How can we account for these fall and winter eggs? An experiment tried by Mr. Cunningham,† in the summer of 1897, on the European lobster, suggests an answer to the question. At Falmouth, England, five female lobsters bearing external eggs about ready to hatch

* Ibid, p. 44.

† Contributions to the knowledge of the national history of the lobster and crab. Journ. Royal Inst. Cornwall, No. XLIV, 1897.

were placed in a floating box in summer time. When their ova had all hatched out these females were kept confined with two males until after October 14, when one was found to have newly spawned. This proves that it is possible for the European lobster to spawn in two successive years, but it does not prove that this is the common habit of the species. It also strongly suggests that these October eggs correspond to the "fall" and "winter" eggs occasionally produced in the American form. By accelerated growth of the ovary, eggs might be laid in fall or winter when not normally due until the summer following. Under such circumstances the ovarian eggs would come to maturity in fifteen instead of twenty-three months. It would be interesting to know when these fall eggs hatch. As already suggested, it is possible that they do not give rise to the regular summer broods. In the American species hatching of larvæ has been casually detected in November and January.

Professor Prince, who rejects the idea of a biennial spawning period, expresses surprise that the notion first advanced by persons wholly untrained and unqualified to form a reliable judgment has received support recently from men of scientific standing. A statement of mine is given a construction which might seem to support the idea that eggs are laid in consecutive years. Thus he says that I found in paper-shell lobsters in July that just after the brood had hatched and the molting was over the eggs in the ovaries were no less than half the size of mature ova. I speak of the diameter of these ova which, if by size is implied their volume, is quite a different matter.*

Again, it is said that I do "not hesitate to affirm concerning this supposed biennial spawning that to prove it requires only the dissection of a female with eggs ready to hatch in June, July, or August, and it will be found that "the ovarian eggs have had, in all these cases, from ten months' to a year's growth"—the very point, in fact, being assumed which requires proof." It would be a work of supererogation to go over in detail this ground again, but I can reaffirm the statement with added emphasis. That the majority of female lobsters which spawn in summer carry their eggs attached to the swimmerets until these same eggs hatch ten or eleven months later is a proved and settled fact admitting of no doubt. It was proved at Woods Hole, and the same experiment was conducted on a large scale by Mr. R. P. Greenleaf, at Southport, Me.† In July and August, 1892, he placed 300 egg lobsters in a pound at that place. In April, 1893, he seined and found the females still carrying their eggs; again, he seined the pound in June, when most of the eggs were hatched. Moreover, I have determined the rate of growth of the external eggs from actual observation, from the time of extrusion to hatching. The external summer eggs are a perfect chronometer for measuring the rate of growth of the ovary during the first period—that is, during the fall, winter, and spring following any given ovulation.

"The fact," says Prince, "that the lobster spawns annually is evidenced by: (1) The fairly uniform proportion of 'berried' females taken season after season. (2) The occurrence of the berried conditions in all sizes of females from 7 inches to 18 inches. It might be expected that females of certain specified sizes would never or rarely be found with eggs were biennial spawning a fact. (3) Exact researches upon

*Ibid, p. 152. †Ibid, p. 58.

allied decapod crustaceans prove the greater frequency of spawning. (4) The rapid growth of ovarian eggs so familiar to embryologists is unfavorable to the biennial theory."

The last two clauses (3 and 4) may be ruled out because this is a matter of fact concerning a specific animal, not a question of analogy with what may or may not occur with other species.

The first clause (1) is somewhat obscure. So far as my observations at Woods Hole have gone, the proportion of berried to adult females without berries is fairly uniform—that is, about one-half the adult females captured in winter and spring are without eggs. Whether this is what Professor Prince means or not, the fact is fatal to the theory of annual spawning. For, upon this hypothesis, during late winter or spring every female of breeding age should carry eggs, excepting here and there a solitary individual which had postponed egg-laying to an extraordinarily late period, or which had met with an accident and lost her cargo. I have never found a single instance of egg-laying in spring. On the other hand, the records of the catches made under my directions by the United States Fish Commission at Woods Hole confirm the statement just made and support the biennial theory of spawning, the proof of which has been given. Thus, in the month of March, 1894, 71 female lobsters 10 inches or more in length were captured in Woods Hole Harbor. Of these, only 9 bore external eggs. How are facts of which this is a sample to be explained on the theory of annual spawning, according to which all such animals should have borne eggs, or, at least, all but a very few which may not have reached maturity? The second statement—"the occurrence of the berried conditions in all sizes of females, from 7 inches to 18 inches," has no bearing on the question of frequency of spawning, since there is no fixed limit at which lobsters mature.* Again, the remark "it might be expected that females of certain specified sizes would never or rarely be found with eggs were biennial spawning a fact," is open to the same objection. New female recruits, of all sizes from 8 inches up, come to their first spawning period every year, and would do so whatever the length of the reproductive cycle.

In conclusion I wish to quote the brief summary which was placed under the description of a drawing of the ovary, which I believe gives a true picture of the growth of the ovarian eggs: "We thus see that a generation of ovarian ova grow very rapidly during the first summer following the last ovulation. They then enter upon a period of quiescence, growing but slowly, like the external embryos during the succeeding winter. At the beginning of the third summer after ovulation this generation of eggs is ready for extrusion. That the spawning periods are thus two years apart is a valid inference drawn from the study of the anatomy of the reproductive organs." †

* Ibid, p. 68.

† Ibid, p. 246.

CAKES OF DRIED "SINARAPAN" (MISTICHTHYS LUZONENSIS). NATURAL SIZE.

Prepared by the natives of Luzon.

NOTES ON FIVE FOOD-FISHES OF LAKE BUHI, LUZON, PHILIPPINE ISLANDS.

By HUGH M. SMITH.

As a meager contribution to the ichthyology of the Philippine Islands, the following notes on a few specimens of fishes recently sent to the United States Commission of Fish and Fisheries are offered. The fish were collected in Lake Buhi, province of Camarines Sur, Luzon, in July, 1901, by Dr. F. W. Richardson, contract surgeon, U. S. Army, and forwarded through the Surgeon-General's Office. Dr. George A. Zeller, acting assistant surgeon, U. S. Army, had previously sent from Lake Buhi specimens of dried fish-cakes made by the natives.

Lake Buhi is described as a beautiful mountain lake, 3 miles wide and 6 miles long, and 500 to 1,000 feet above the sea. It is reputed to be very deep, and is said to have been formed by a volcanic upheaval before the Spanish occupation, when one side of Mount Iriga was blown out, and hills of lava were scattered for miles to the southeast of the mountain.

All of the species hereafter referred to are used for food. The size of some of them indicates that nothing is too small or insignificant for the Filipinos to eat. In Lake Buhi very few fish are caught with hook and line, the native appliances being a fine-meshed net used as a seine and a trap made of bamboo.

Mistichthys luzonensis H. M. Smith. "*Sinarapan.*"

In an article (*Science*, January 3, 1902) entitled "The Smallest Known Vertebrate," the writer gave a preliminary notice and brief description of this new genus and species of goby from Lake Buhi. The genus *Mistichthys* (μεῖστος, the smallest; ἰχθύς, fish) may be diagnosed as follows:

Body elongate, compressed. Head rather large. Dorsal fins widely separated, the anterior very low, containing 3 weak spines joined by a membrane, the posterior high, with 8 or 9 branched rays; anal fin similar to soft dorsal; pectorals long and rounded; ventrals 1, 5, coalescent, not adnate to abdomen; caudal well developed, bluntly pointed. A single series of rather long, curved conical teeth in each jaw. Scales large, ctenoid. Gill membranes joined to isthmus. A large genital papilla in each sex. Coloration plain. Size minute, the males rather smaller than females.

Mistichthys luzonensis may be more particularly described as follows:

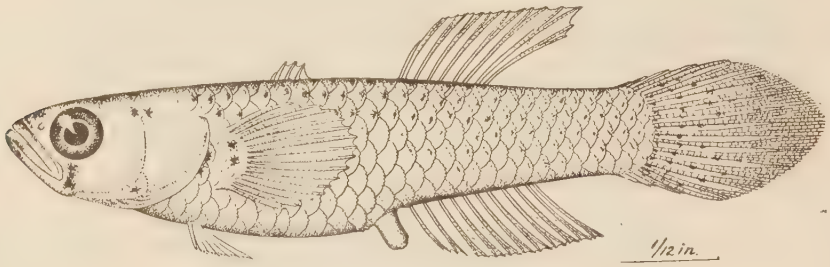
Form elongated, compressed, tapering but slightly to the rather wide caudal peduncle. Depth of body equals about one-fourth total length, the female being slightly deeper than the male. Head large, its length contained 3.3 times in body; mouth large, oblique, the maxillary extending to a point under anterior border of pupil; lower jaw slightly longer than upper, the chin projecting; teeth short and numerous, arranged in a single row in each jaw; eye large, 3.3 in head; snout blunt, two-thirds diameter of eye; interorbital space about one-half eye; branchial membranes not united and joined to the isthmus. The dorsal fins are separated by an interval rather less than half the head; the anterior consists of 3 weak spines and a rudiment adnate to the first spine, and is very low, its height being less than half diameter of eye; the second dorsal contains 8 or 9 rays, of which the posterior

are longest, and is comparatively high, the longest rays being nearly two-thirds length of head and 5 times length of dorsal spines; the origin of anterior dorsal is 0.4 distance from end of snout to base of caudal, that of the posterior dorsal is 0.4 distance from base of caudal to end of snout, and over origin of anal. Anal fin large, of 11 branched rays of nearly equal length, rather less than height of second dorsal. Pectorals two-thirds as long as head, rounded, with broad base, the central rays extending as far as vent; rays 15. Ventrals 1, 5, short, coalescent, not adnate to abdomen. Caudal large, central rays produced, its length equal to five-sixths of head. Genital papilla in the male slender, tapering, longer than first anal ray and 1.5 times diameter of eye; that in the female half as long and twice as broad as in the male. Scales large, strongly ctenoid, 23 or 24 in lengthwise series and 6 in transverse series.

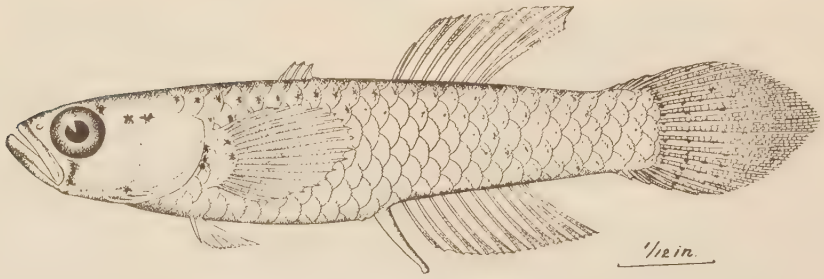
Colors: In life, apparently almost transparent; muzzle black; a black line at base of anal; back and head sparsely spotted with black; a narrow black stripe under eye.

Average length about 12.5 mm., the males somewhat smaller than the females.

Types (Nos. 50303 and 50304, U. S. National Museum), collected in Lake Buhi, Luzon, Philippine Islands, July 5, 1901, by Dr. F. W. Richardson.



MISTICHTHYS LUZONENSIS Smith. Female. Enlarged 8½ times.



MISTICHTHYS LUZONENSIS Smith. Male. Enlarged 8½ times.

This is apparently the smallest known species of fish. The average length of females among the specimens at hand is 13.5 mm., the minimum under 12 mm. The average length of males is 12.5 mm., the minimum under 10 mm., and the maximum 13.5 mm. The average length of 50 specimens taken at random, both sexes about equally represented, was 12.9 mm.

That these specimens are mature is shown by the presence of ripe ovarian eggs and by the extrusion of perfect eggs when the fish were placed in the preserving fluid. The average diameter of the extruded eggs is 0.5 mm.

The shape of the genital papillæ suggests that the eggs are deposited in crevices or under objects, and there fertilized.

Prof. H. V. Wilson, of the University of North Carolina, has examined this fish with reference to its eggs, and communicates the following notes thereon:

"The ripe ovarian egg is uniformly filled with granular yolk. It is of a rounded shape, frequently elliptical in outline. It lies inside a comparatively thick shell, which has an irregularly polyhedral shape. One facet of the shell is convex and bears a small, rounded depression, from which radiate

dichotomously branching fibers, which cover all facets of the shell except the one opposite the depression. The fibers adhere closely to the surface of the shell and may be continuous with it. Around the margin of the bare surface the fibers may extend beyond the egg, lying in an intricately coiled condition in the spaces between the eggs. The fibers are probably to be looked on as ridges of the eggshell which become free with continued growth.

"The ripe eggs are packed together closely in the ovary, adhering by their flattened surfaces. Between and beneath them numerous small ovarian ova, with relatively large nucleus and nucleolus, are present. Such small ova have not yet developed a shell. I believe the ripe eggs are arranged in a single layer around the axial cavity of the ovary, with the convex depression-bearing surfaces facing the cavity. The fibers or filaments suggest, of course, that the egg is attached to something during its development.

"In the discharged eggs examined the filaments project from one side in the form of a tuft. No signs of segmentation could be made out in surface view of eggs in clove-oil, and yet the shape of the blastoderm was so embryo-like that I thought it necessary to section a mass of the eggs taken directly from the fish. The sections permit the blastoderm to be seen distinctly as well as the yolk. The blastoderm is much thicker on one surface of the yolk than on the opposite surface, but is quite unsegmented. I have examined a large number and find no trace of segmentation.

"The highly developed egg-membrane, with its filaments, is certainly a very unusual feature. I know of no similar case, but I have not at hand literature which would enable me to say whether or not such a membrane has been described. The disk-like area from which the filaments radiate is exceedingly thin in the center, but is not perforated. I can not make out a micropyle. The appearance of several eggs indicates that when the egg is laid an outer membrane, with the filaments, is split and recurved, leaving the egg surrounded by a thin membrane, at some point of which the micropyle should be.

"There is certainly nothing in the appearance of the eggs (egg-membrane, yolk, blastoderm) to suggest that they develop in the mother. The complicated egg-membrane, on the contrary, strongly suggests that the egg develops outside the mother, attached by filaments to some body. All this is, of course, negative evidence."

An interesting fact regarding this species is that it is a food-fish of considerable importance. In forwarding samples of the fish as dried for food, Dr. Zeller wrote as follows:

"I inclose herewith samples of a strange article of diet greatly relished by the Bicols, among whom I have been stationed for the past eighteen months. Rice and fish are the staple articles of diet for most Filipinos, and in the provinces of the Camarines there is little variation from these two. Fishes of every size and many varieties are prepared in every conceivable form, but the samples inclosed are unique in that they are found here and nowhere else. * * * Many varieties of fish abound in the lake, but by far the most numerous are these minute specimens. They are called in the native Bicol tongue 'sinarapan,' and when dried in the sun on a leaf are called 'badi.' They are caught by a large sheet of close web, which is dipped under wherever a school congregates. They are put into tightly woven baskets from which the water soon drains, leaving a compact mass of fish. They are not minnows or immature fish. They are adults and attain no greater size. The natives buy them eagerly; and when the little fleet of fishermen return from their morning's quest and place their baskets upon the ground on the market place, they are instantly surrounded by a crowd of waiting children who, armed with every sort of dish, are anxious to take home the family meal. They bring three or four potato tubers, a handful or two of rice, or a few copper pennies, and in exchange receive about a pint of fish. In the kitchen the fish are made up with peppers or other spiced herbs, and they do not taste bad. The soldiers have become quite fond of this food, and liberally patronize the little native restaurants where it is served."

Gobius sternbergi, new species.

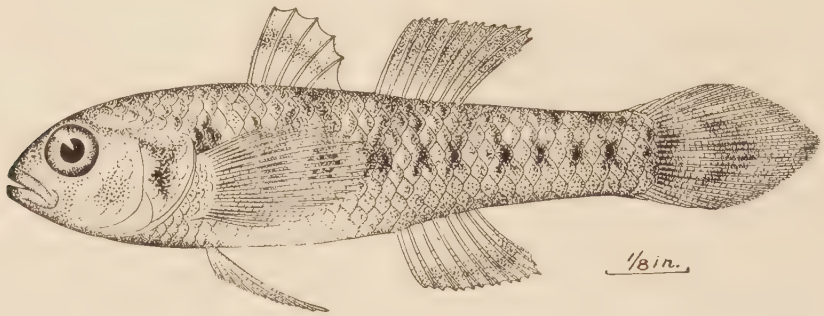
Form elongate, rather robust, slightly compressed, the depth contained 4 times in length. Head rather large, its length about one-third total length of body; mouth rather small, terminal, nearly horizontal, the maxillary not extending to vertical from anterior edge of pupil; snout short and very blunt, about three-fourths diameter of eye; eye large, superior, bulging, less than 4 in head; interorbital one-half eye. Teeth in upper jaw in about 3 irregular rows, of which the outer row contains the largest teeth; teeth in lower jaw in a band, some larger than others and canine-like. Branchial membranes broadly united to the isthmus. D. v, 8; A. 8; caudal pointed; ventrals long, extending nearly or

quite to vent; pectorals long, the central rays produced and extending opposite origin of second dorsal. Scales large, those on sides, abdomen, and most of back finely ctenoid, those on anterior part of back mostly cycloid; posterior edge of scales angular; opercle, preopercle, and top of head as far forward as interorbital space covered with large cycloid scales; scales in lateral series 25 or 26, in transverse series 8; 12 scales before anterior dorsal.

Colors: Head, sides, and back dusky, the under parts white. Sides marked by about a dozen short, irregular, vertical, blackish blotches, a prominent one above base of pectorals; muzzle dark; a dark area on opercle; anterior dorsal pale at base, blackish distally; second dorsal irregularly marked with dark stripes; anal and caudal dusky; pectorals and ventrals plain.

Types (No. 50536, U. S. National Museum), 6 specimens 20 to 27 mm. long, collected in Lake Buhi, Philippine Islands, by Dr. F. W. Richardson, July 5, 1901.

This species seems to agree with none of the 20 or more species of *Gobius* already described from the Philippine Islands. It is named for Dr. George M. Sternberg, Surgeon-General of the United States Army.



GOBIUS STERNBERGI, new species.

Hemirhamphus cotnog, new species. *Half-beak; "Cotnog."*

Body rather slender, the depth contained 8 times in length (from end of upper jaw to caudal base); sides somewhat compressed, vertical; thickness of body one-half less than depth; length of head (with lower jaw) 2.3 in total length of body; length of lower jaw (beyond extremity of upper jaw) rather greater than remainder of head and 4.4 in body; premaxillaries broader than long, their length less than eye; eye large, 1.6 in postorbital space; top of head flat; interorbital 1.2 width of eye. Dorsal very low, the longest of the 12 rays not exceeding eye; dorsal origin slightly in advance of anal; anal very short, but much higher than dorsal; 13 anal rays, the first short, the next 4 long and broad, the middle rays shorter than the last, the free margin of the fin incised and nearly vertical; caudal rounded; ventrals very short, less than eye, much nearer to base of caudal than to axil of pectorals; length of pectorals slightly exceeding depth of body. Scales 65 in lengthwise series, about 9 rows between dorsal and anal.

Colors (in formalin): Greenish above, the scales with dark edges; white below; a silvery lateral stripe increasing in width from before backward; dorsal dusky, other fins plain; lower jaw black.

Type (No. 50537, U. S. National Museum), a specimen 106 mm. long, collected in Lake Buhi, July 5, 1901.

The writer hesitates to add another species of half-beak to the already large number of real and nominal forms recorded from oriental waters, but is unable to make other disposition of the specimen in hand. The combination of reduced number of dorsal and anal rays, small scales, and rounded tail with the modified anal rays suffices to distinguish it.

This fish is called "cotnog" in the Bicol tongue, and is said to attain a weight of 1½ to 2 pounds in Lake Buhi.

Anabas scandens (Daldorf). *Climbing Perch; "Attas"; "Pogo."*

Two young examples, 4 and 4.5 cm. long, are referable to this species. Head 2.5 in length; depth 2.5 in length; D. XIX, 8 and XVIII, 9; A. X, 9 and XI, 9; scales 31. Color greenish, lighter below; body

marked by about 12 narrow, dark vertical stripes; a blackish spot at base of caudal surrounded by a lighter area. The denticulations on the preorbital are concealed by a fold of skin, and the spines on the opercle are less numerous and less strongly developed than in a specimen of similar size in the U. S. National Museum from Ceylon and than in examples figured by Bleeker and Day, but in other respects these specimens conform with the descriptions of *A. scandens*.

Dr. Richardson states that this fish is known as "attas" at Buhi and as "poyo" in other Bicol towns. It is reported to attain a weight of 1½ to 2 pounds. If this is correct, the Lake Buhi fish is larger than the specimens recorded from any other waters.

This is the celebrated climbing perch of the fresh waters of India, China, and the East Indies. By means of a freely movable opercle, it is enabled to ascend trees for a distance of 5 to 7 feet; and the possession of an accessory breathing apparatus makes it adapted to both an aquatic and a terrestrial existence. The fish is said to die when prevented from exercising its aerial respiration.

The climbing fish is highly esteemed for food, and in India is extensively employed for stocking ponds.

Ophiocephalus striatus Bloch. "*Oroon*"; "*Terebog*"; "*Talosog*."

Two young specimens, 73 and 87 mm. long, respectively, were received. Head 3 in length; depth 6 in length; eye 7 in head, 1.5 in snout; dorsal 44; anal 26; scales 53–15.

According to Dr. F. W. Richardson, this fish in Lake Buhi attains a weight of 5 pounds and is called by the Bicols "ovoon" when young, and "terebog" or "talosog" when grown. It is an important food-fish of the lake, probably exceeded in importance only by the "sinarapan."

This species is known from other parts of the Philippine Islands, and is widely distributed in the fresh waters of China, Burma, and India. According to Day (Fishes of India), it attains a length of 3 feet or more, takes a bait, especially a frog, very readily, and is said to rise to a salmon fly. Day gives the following general information about the *Ophiocephalidæ*, or serpent-headed fishes:

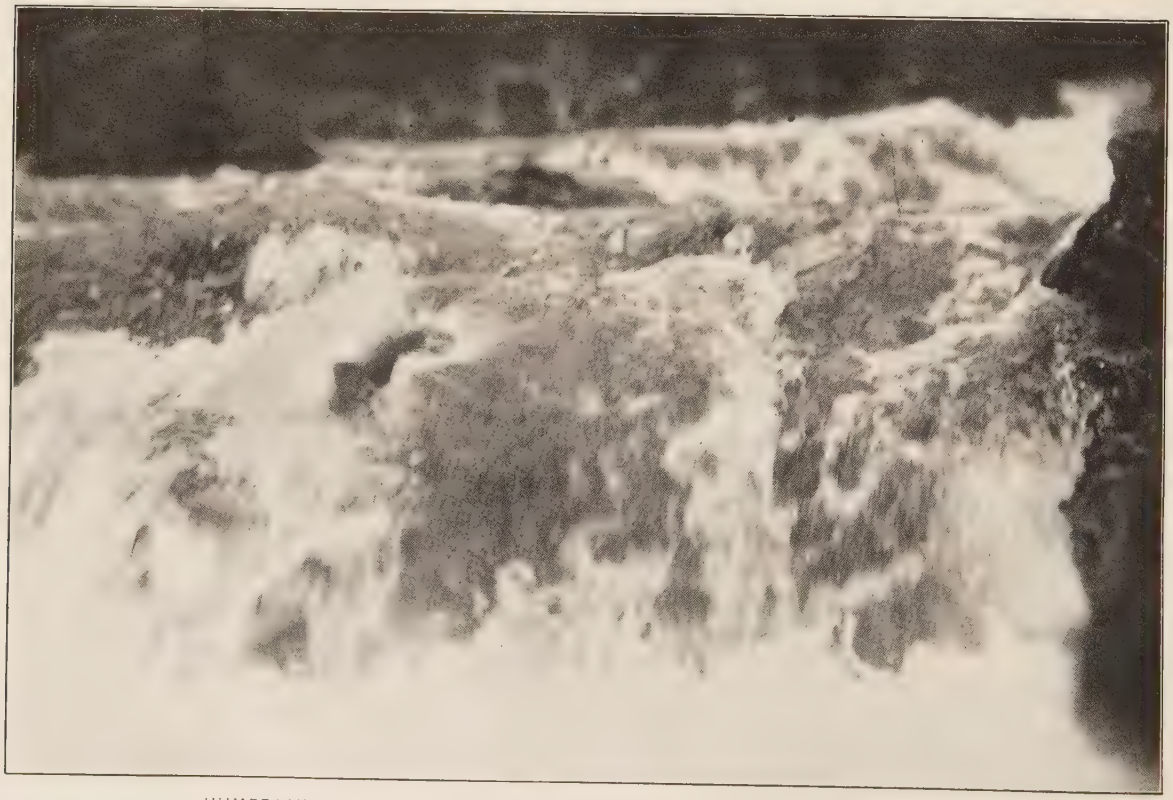
The *Ophiocephalidæ*, having hollow cavities in their heads and an amphibious mode of respiration, are able to exist for lengthened periods out of their native element and can travel some distance over the ground, especially when moist. They possess an accessory cavity to the gills, and are able to respire direct from the atmosphere. Jugglers both in India and China exhibit these fishes walking on the land, and children amuse themselves by making them crawl along. "In China they are often carried alive in pails of water and slices are cut for sale as wanted, the fish selling dear whilst it retains life, while what remains after death is considered as of little value." Owing to the breadth of their bodies, they are able to progress in a serpentine manner, chiefly by means of their pectoral and caudal fins, first one of the former being advanced and then its fellow. They are exceedingly difficult to retain in aquaria, unless the top is covered over, as otherwise they manage to escape and proceed on their travels. These fishes appear to be monogamous, some breeding in grassy swamps or the edges of tanks; some in wells or stone-margined receptacles for water, and others again in holes in the rivers' banks. When very young the fry of all these species keep with and are defended by their parents, but as soon as they are sufficiently strong to capture prey for themselves, they are driven away to seek their own subsistence; those which are too obstinate to leave being, it is believed, eaten by their progenitors. The varieties which live in tanks and swamps delight in residing at their shallow and grassy edges, so that they can take in with ease their modicum of air for the purpose of breathing, or capture any frog that may incautiously venture too close to their lair. These fishes appear to be well adapted for pisciculture, as some grow to a large size, whilst all are good eating. The smallest, *O. gachua*, attains about a foot in length and thrives in almost any situation. They are rather voracious, but appear to consider a frog, mouse, or rat as luscious a morsel as a fellow fish. They assist in keeping water pure by destroying either animal or vegetable substances which may come in their way.

ALASKA SALMON INVESTIGATIONS IN 1900 AND 1901.

BY

JEFFERSON F. MOSER,

Commander, United States Navy.



HUMPBACK SALMON ASCENDING LOW FALLS, LITNIK STREAM, AFOGNAK ISLAND.

SALMON INVESTIGATIONS OF THE STEAMER ALBATROSS IN THE SUMMER OF 1900.

By JEFFERSON F. MOSER,
Commander, United States Navy, Commanding.

INTRODUCTION.

The main features of the work of the *Albatross* during the summer of 1900 were a continuation of the exploration and examination of the stream and lake systems of Alaska, their general features and characteristics so far as they relate to salmon and other fishes, spawning-grounds, condition and nature of the water, character of shores and vegetation, the species of salmon entering and their movements, the time and duration of runs, the size and abundance of fish, waste species, signs and causes of depletion, the mortality of different species on the spawning-grounds, natural and artificial obstructions to the passage of fish, fishing methods and their relation to the maintenance of supply, and data relating to conditions for hatcheries. At the canneries statistics were obtained of the streams fished by them, and detailed statistics relating to the men, vessels, boats, and apparatus employed in the fisheries, together with the catch and pack of the various species for the years 1898, 1899, and 1900. The photographic and hydrographic works, so far as they relate to the subject, were also continued.

Except in the interior waters of southeastern Alaska, the salmon streams lie in unsurveyed localities usually dangerous to approach without local knowledge, and, while we were able when detained in port to add something to the hydrographic information by surveys and sailing directions, yet but little was accomplished in a field where much remains to be done.

Before proceeding with my report, I desire to express my appreciation of the work performed by the officers of the *Albatross* and the courtesies extended by those interested in the salmon fisheries. Lieut. Hugh Rodman, U. S. N., besides his duties as executive and navigating officer, was indefatigable in conducting the stream and lake explorations and in making the local surveys. Ensigns A. J. Hepburn, U. S. N., and Cyrus R. Miller, U. S. N., assisted in the field work. Ensign Clarence S. Kempff, U. S. N., besides his duties in charge of the engineer's department, made a number of the stream and lake examinations and assisted on the surveys. Mr. H. C. Fassett assisted me generally in the collection of data, and had charge of all the photography, in which he rendered valuable service. All performed their duties to my entire satisfaction.

My thanks are due to the superintendents of all the canneries we visited for the courteous manner in which we were everywhere received and for the assistance they offered. No obstacles were placed in our way, and, while they did not volunteer to tell us all they knew about the business, they cheerfully answered all the questions of which they had any knowledge.

As this report will be an addition or appendix to my report on the same subject, published under the title The Salmon and Salmon Fisheries of Alaska, 1899, it is unnecessary to repeat here the subjects therein treated, and which remain unchanged. Reference is therefore made to that report for the introductory remarks, the district divisions, the manner of conducting our investigations and the difficulties encountered, the species of salmon and their various names, the relative importance of the species, the salmon runs, spawning habits and enemies; the history of the canneries and the canning industry; salteries, fishery and cannery methods; the fisheries, labor, weight of fish, labels and brands, market prices, cans and boxes, the depletion of streams, barricades, and salmon laws; relation of the salmon fisheries to the Indian; complete statistics, and descriptions of all the canneries and streams visited from Dixon Entrance to Bering Sea.

The first day of the fiscal year found the *Albatross* at Unalaska, having arrived there June 29, via Japan and Kamchatka, from a cruise of scientific investigation in the South Pacific Ocean.

On account of the rush to the gold fields at Cape Nome, we had to await our turn to coal, finishing on the evening of July 3, when we entered Bering Sea once more and laid the course for Bristol Bay.

The following was our itinerary during the investigation:

Bering Sea district:
- Left Unalaska July 3.
- Bristol Bay, July 5–19.
- Unalaska, July 21–24.

Kadiak and Chignik district:
- Chignik Bay, July 28–29.
- Alitak Bay, July 30–August 7.
- Karluk, August 7–9.
- Uyak, August 9–11.
- Afognak, August 11–16.

Southeast Alaska district:
- Sitka, August 19–21.
- Killisnoo, August 21–22.
- Pyramid Harbor, August 22–23.
- Chilkoot Inlet, August 23–25.
- Taku Inlet, August 25–26.
- Taku Harbor, August 26–27.
- Port Snettisham, August 27.
- South Bay of Pillars, August 28–September 2.
- Shipley Bay, September 2–4.

Southeast Alaska district—Continued.
- Duncan Canal, September 5–8.
- Point Highfield, September 8–10.
- McHenry Inlet, September 10–12.
- Zimovia Strait, September 12–13.
- Union Bay, September 13–14.
- Ward Cove, September 14–15.
- Loring, September 15–17.
- Yes Bay, September 17–21.
- Karta Bay, September 21–23.
- Loring, September 23–24.
- Ketchikan, September 24.
- Boca de Quadra, September 24–25.
- Metlakahtla, September 25–27.
- Comox, British Columbia, October 2–3.
- Tacoma, Washington, October 4–17.
- Quartermaster Harbor, Washington, October 17–21.
- Comox, British Columbia, October 24–26.
- Sausalito, Cal., October 30.

NATIVE VILLAGE AND UKALA RACKS, ON BLUFF TO WESTWARD OF ARCTIC PACKING COMPANY (A. P. A.), NAKNEK RIVER.

BRISTOL BAY DISTRICT.

TOPOGRAPHIC AND GEOGRAPHIC FEATURES.

The commercial salmon fisheries included in the division laid out in my previous report as the Bering Sea district are confined entirely to Bristol Bay, and if the wide limits ascribed by some to this bay are accepted, the canneries and fisheries are all in the northeast section or on the rivers that empty there. One authority states that "Bristol Bay may be said to include all that part of Bering Sea lying east of a line drawn from the northwest cape of Unimak Island to the Kuskokwim River." In my opinion, a better western boundary, topographically, would be a line from Port Moller to Cape Newenham.

The commercial salmon fisheries of this district are on the Ugashik, Egegak, Naknek, Kvichak, Nushagak, and Wood rivers, and their sea approaches. These rivers are all large, with large lake sources, and, except Wood River, drain the western slopes of the mountain range that traverses the Alaska Peninsula and extends along the western border of Cook Inlet.

This mountain range lies close along the eastern side of the peninsula, and at intervals it rises into volcanic peaks of considerable height, some of which, by their smoky wreaths, still indicate activity. The greater part of the ridge is snow-covered, and its northern extension forms the mountain masses which extend along the western side of Cook Inlet, where the volcanoes Iliamna (12,000 feet) and Redoubt (11,000 feet) rise conspicuously above the lower masses.

This ridge is not altogether continuous; there are a few breaks which admit of portage, and as the end of the peninsula is reached there are a number of depressions. It is said that formerly sea-otter hunters from Bristol Bay, by ascending the Kvichak River to Lake Iliamna, made a portage to Kamyshak Bay. In the early days the Russian *promyshleniks* found their way from Kadiak Island to Bristol Bay, using the pass across the peninsula from Katmai to the headwaters of the Naknek.

For many years the Russian-American Company transported their merchandise across from Katmai, thus reaching the Bristol Bay, Nushagak, Yukon, and St. Michael regions. At Chignik there is a well-known portage, and beyond to the westward there are several which are still used. The mountain range shows two distinct benches of upheaval, and the theory has been advanced that in former ages, not very remote geologically, these depressions were submerged, forming waterways into Bering Sea, and the present ridge was then broken into islands, of which the present Aleutian chain is a continuation.

As the divide of this ridge lies close to the eastern shore, the watersheds on that side are short, the streams are numerous and small, and there are no great lakes and rivers. At Chignik, where probably the largest river on the eastern side has its outlet, there is a depression in the mountain chain, and the lakes in which the river has its source lie in a plain beyond, to the westward of the mountain masses. It is here that the portage referred to exists. It extends from the Chignik lakes to a stream which empties into Bering Sea near Port Haiden.

On the western slope of the peninsula there is a different topographical condition. The shore generally is low, with here and there an isolated mountain or projecting

spur, and in the vicinity of the larger rivers, where the peninsula expands to a width of from 60 to 90 miles, the mountains in the distance are visible only on a clear day. Along this shore there is an occasional high bluff which marks the sea terminus of a ridge of hills.

From the western shore to the mountains the country is a gradually ascending, rolling plain, hillocky in places, dotted with lakes fed by the glaciers and melting snows in the east, with much marshy tundra cut up by streams and mud sloughs.

It is on this western watershed of the Alaska Peninsula that the large lakes, Ugashik, Becharof, Illiak, Naknek, and, on the northern extension, Iliamna and Clark, are situated. These form the sources of the rivers on which the salmon fisheries in Bristol Bay are located.

Referring to the topographical features of the Bering Sea district, the Russian missionary, Veniaminof, says:

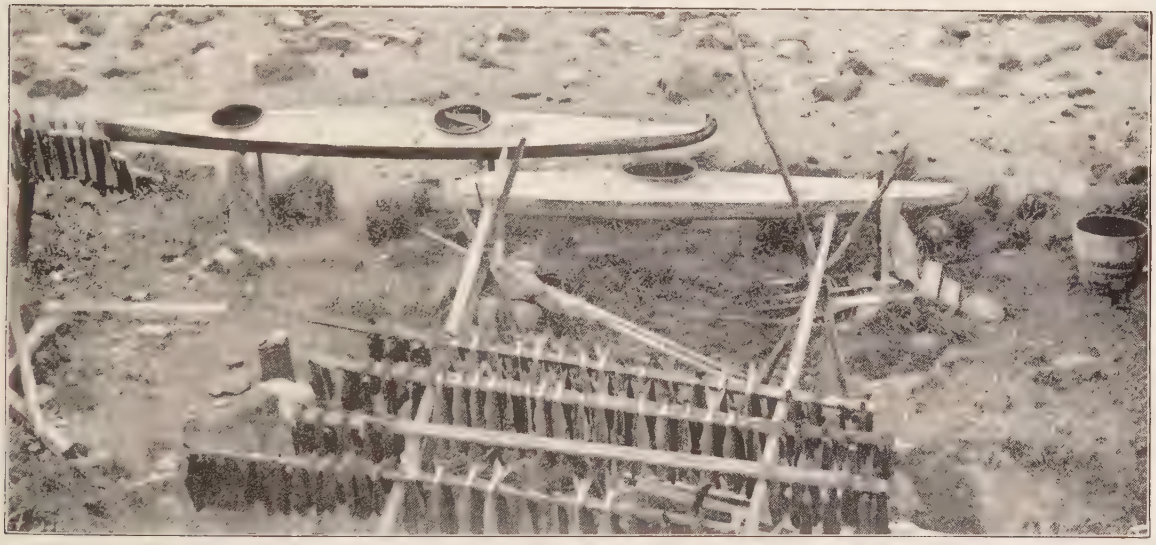
> Slight elevations can be found along the whole extent of the American coast of Bering Sea; they are in nearly all cases connected with the mountains in the interior. If the observer ascends to a height the country appears to him like a heaving ocean suddenly become stationary, with its waves transformed into sand and mud; these waves are now covered with vegetation, but their outlines are still very striking. In the midst of this dry sea we find occasionally high, rocky islands entirely separated from the neighboring hills.

Of the interior of this country no exact information is at hand, and it still awaits the intelligent explorer. But little information can be obtained from the natives, and not much more from the prospector who occasionally finds his way into the interior, or the worthless squaw man, who at times is infused with sufficient energy to look for game.

The population is not large and consists of Innuits or Eskimos, who live in small villages located on high ground, on hills or bluffs bordering a river or lake. They subsist by hunting and fishing, and, when located near a cannery, earn good wages, if they desire to work. Their food is largely salmon, though seal, beluga, and walrus also enter their diet when they can be obtained, and occasionally a deer or moose is taken. Their food is all preferred "high"—not high in the sense of the epicure, but rotten; rancid oil is generally cooked with it or used for sauce. The decaying carcass of a whale cast on the beach attracts the natives for many miles, and a grand feast is held over it; rotten salmon heads are a *bonne bouche*. They are very filthy in their habits and live in very primitive dwellings, made by forming a shallow circular excavation and erecting over it a framework of driftwood, or whale ribs, with double walls filled with earth and stones and covered over with sod. A small aperture is left in the apex for the escape of smoke, though many of their dwellings now have side openings with a small window. The outside, or the roof, as it were (for all above ground is rounded in shape), is a gathering place for children and dogs, and is surrounded by mud and offal. The entrance is a low square hole, to enter through which one must stoop very low, or crawl, and then pass through a gallery or tunnel into the inner chamber, which is irregular in shape and from 10 to 15 feet in diameter.

In the center, and under the smoke opening, is the fireplace, and along the walls are couches of skins or mats slightly elevated above the floor; frequently there are several of these dwellings connected by tunnels, all having one common entrance. Storehouses are built on driftwood posts 4 or 5 feet from the ground; in these the

NATIVE BARABARA SOD HOUSE, AND STORE HOUSE, NEAR NAKNEK RIVER.



BIDARKA AND KAYAK ON BEACH, UGASHIK RIVER.

UKALA RACKS NEAR CANNERY OF ARCTIC PACKING COMPANY (A. P. A.), NAKNEK RIVER.

On the left is a typical diminutive tent, such as is used by the Bering Sea Eskimos and Aleuts.

winter supply of ukala is kept, inaccessible to dogs, foxes, and wolves. Salmon are dried in large numbers to make ukala for the winter supply.

In the interior, where it is obtainable, timber enters largely into the construction of the house. Near trading posts the dress is a combination of native and European, though many still wear skin coats (parkas) and skin trousers and boots. They travel by land with dog teams, and by water in skin boats (kayaks and bidarkas).

The Bristol Bay salmon rivers, of which we are now treating, are all large and flow great volumes of water. The banks are frequently low, cut by numerous mud sloughs, in places flooded at very high water, and at low water uncovering a beach of mud on which a landing can not always be made. The rolling tundra through which these rivers flow looks like a grass-covered plain, but it is all cut up into hillocks and hollows, marshes and ponds, making it generally impassable, except during the winter. Throughout this section travel, except by boat, must be confined to the winter months, when everything is frozen solid. The country is treeless. A belt of timber stretches from the northward to Lake Becharof and then makes a wide circuit and impinges on the Nushagak. The rivers widen considerably at the mouth, forming broad, shallow bays, though still called rivers at the canneries. As there is a rise and fall of the tide of from 18 to 24 feet, the change in the appearance of the tidal area at high and at low water is striking, for at high water the lower courses are filled to the banks, forming rivers as wide or wider than the Mississippi, while at low water they are confined to narrow, shallow channels running between uncovered shoals and banks. This subject will be referred to later under the heads of the several rivers.

As there seems to be some confusion in the geographical division of some of the rivers and bays, it is deemed advisable to state here the application of certain names in this report.

By some authorities the large arm of Bristol Bay, which receives the waters of the Nushagak and Wood rivers, is called the Lower Nushagak River. It is about 30 miles in length, 13 miles in breadth at the seaward entrance, and 4 miles at the head, and does not in any way partake of the nature of a river. Therefore this body of water, opening into Bristol Bay between Protection Point and Etolin Point and extending northward to the junction of the Nushagak and Wood rivers, will be called in this report Nushagak Bay, and the two rivers named will be regarded as emptying into the head of that bay.

The next great arm of Bristol Bay to the eastward of Etolin Point and extending to the northeastward will be called Kvichak Bay, for the seaward boundary of which will be taken a line from the southern point of entrance of the Egegak River to Etolin Point, and for the northern extreme a point above Koggiung, where the Kvichak River is confined in banks within the usual acceptation of that term. The Lockenuck, Kvichak, Naknek, and Egegak rivers will be considered as entering Kvichak Bay.

EARLY RECORDS OF SALMON FISHERIES IN BRISTOL BAY.

The history of the salmon fisheries of Bristol Bay for commercial purposes is given under the several cannery headings. The earliest record in the history is the salting of salmon on the Nushagak by the schooner *Neptune* in 1883, and the erection of cannery buildings that year for the Arctic Packing Company, which made a trial

pack of 400 cases the year following (1884). It is noticed, however, that Petroff, in the census report of 1880, states:

> The salmon family, the great feeder of all the Alaskan people, frequents in astonishing numbers the Nushagak and other streams emptying into Bristol Bay. The facilities for building traps and weirs are also extraordinary, and American fishermen have for some years been engaged here every season in reaping a rich harvest and shipping the fish, salted in barrels, to market. Hundreds of barrels have been filled with a single clean up of a trap. The only drawback to this business is the short period over which the run extends, necessitating the employment of a very large number of hands while it lasts. * * * Exports from this section have thus far been limited to from 800 to 1,200 barrels of salted salmon per annum from the Nushagak River.

It is probable that this latter reference was to the salting done by traders on a limited scale. The Alaska Commercial Company, or their agents, salted salmon at various stations prior to 1880, and, as they had an important station at Fort Alexander, on the Nushagak, it is probable that some salting was done there.

FISHING METHODS AND FISHERMEN.

Two methods only are employed in taking salmon for commercial purposes in this district, viz, by gill nets and by traps, and both are well adapted to the local conditions.

The strong currents and comparatively narrow deep-water channels, together with the discolored water, permit the use of gill nets with great success. The dimensions of the nets vary according to the depth of water and the individual ideas of the different cannery superintendents. For redfish the length varies from 75 to 80 fathoms; the depth from 20 to 26 meshes, and the mesh from 6⅛ to 6¼ inches stretched. For king salmon the length is from 120 to 125 fathoms, the depth 24 meshes, and the mesh 9¼ inches stretched. Floats are rigged 3 feet apart and leads 2¼ feet apart. The average value is about 65 cents per fathom, depending on the market and the quantity purchased. The large companies use a great amount of web, and have special arrangements with the manufacturers. By watching the market closely and buying when the price is low they have a great advantage over small operators.

The gill-net boats used on the Nushagak and the Ugashik are regular Columbia River boats, built in San Francisco at an average price, complete, of $200. The usual dimensions are: Length, 25 feet 1 inch; beam, 7 feet 8 inches; depth, 2 feet 6 inches; capacity, 300 cubic feet. They have a centerboard and spritsail, and will carry, as an extreme, 1,400 redfish. The boats used on the Kvichak, Naknek, and Egegak are flat-bottom double-enders, about 1 foot longer than the Columbia River boats, but have the same rig and the same capacity, and on the water resemble them very closely. Their value is about $100, complete. Two men form a gill-net crew—a netter and a boat-puller. They work on tides, and when the fish are plentiful remain near the canneries, but when the run is slack they may drift 15 or 20 miles away.

Traps, used extensively in the Bristol Bay district, are a subject for criticism throughout Alaska. They are expensive to build and maintain, but have many advantages to the canner. The great benefit of a trap is not only that it fishes day and night, but, if the run is heavy for a few days and the cannery fully supplied by the gill-netters, the fish in the traps can be held for a time until the catch of the gill-netters is slack. These advantages have frequently led the trapmen beyond the limits

of the law, and the time has come when the use of traps must be regulated and the law enforced, or else they must be abolished. Having in mind now the whole of Alaska, it is my opinion that if this be not done they will work a great injury to the fisheries.

Columbia River salmon boat.

Columbia River salmon boats and flat bottom salmon skiff.

Traps catch not only the salmon wanted, but all other species of salmon and other fish not wanted. Practically all fish taken in the traps, except redfish, are waste, and until one sees the tons of this waste product, one can not realize the magnitude of this giant octopus that grasps everything in its tentacles.

Fish were very plentiful this year, and the gill-netters were able to supply most of the fish used. It was said on this account that traps took more fish than were

wanted, and that they were frequently opened to let the impounded fish escape. This statement may be true, but there never was a cat that held a mouse with more tenacity than a canneryman holds a salmon, and it is doubted if a salmon of choice species is ever allowed to escape as long as it is fit to be put inside a tin can.

I have said here that practically all fish taken in the traps, except redfish, are waste. This should be slightly modified, though practically it is true; yet, in justice to the cannerymen, it may be said that the records of the past few years show that, besides redfish, on the average less than 8,000 cases of king and 8,000 cases of all other species were packed per year in the whole Bristol Bay district, and some of these no doubt were taken in traps.

There is a question arising in my mind which now can only be stated and left for the future to decide, as follows: Traps take all fish of all sizes; gill nets take only the large fish; will gill-net fishing result in decreasing the size of the fish?

In one locality trap men informed me that trap fish are more expensive than gill-net fish. In another place it was said that this year two gill-net boats secured more fish than one trap, but when asked why the traps were maintained the reply was that the fish were held in the traps until wanted.

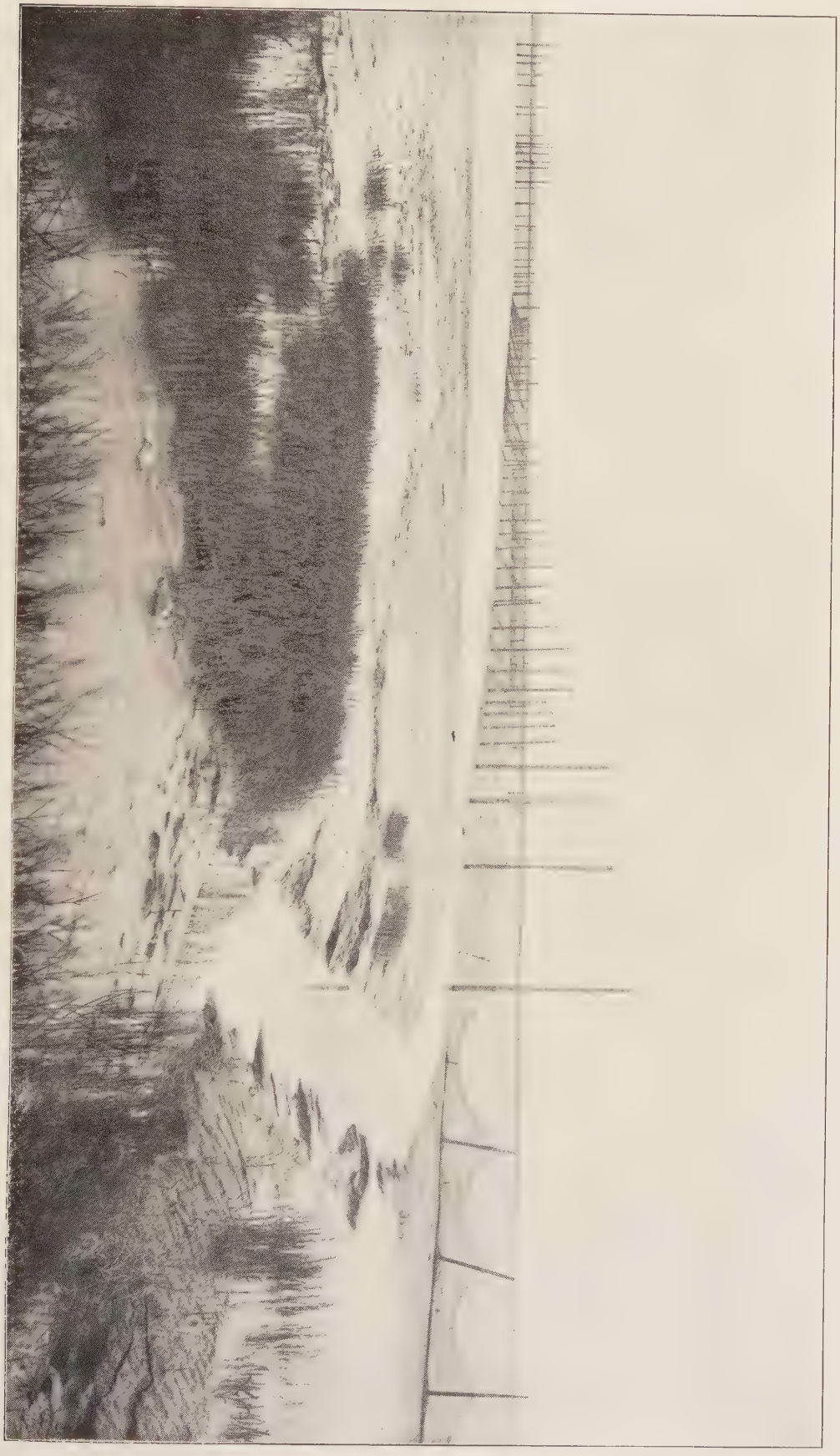
One canneryman, whose resources seemed limited and who did not feel able to maintain traps, frankly said that traps should be abolished; but, when asked if he believed that traps were injurious to the fisheries, he was equally frank in saying "No." The motive is evident.

The traps used are of the general type illustrated in my report of 1897, page 170. They consist of the usual shore and channel leads, with hearts and pots, but there are all kinds of variations to meet local conditions or the fancy of the "trap boss." Some have two pots and some have additional appendages in the shape of corrals.

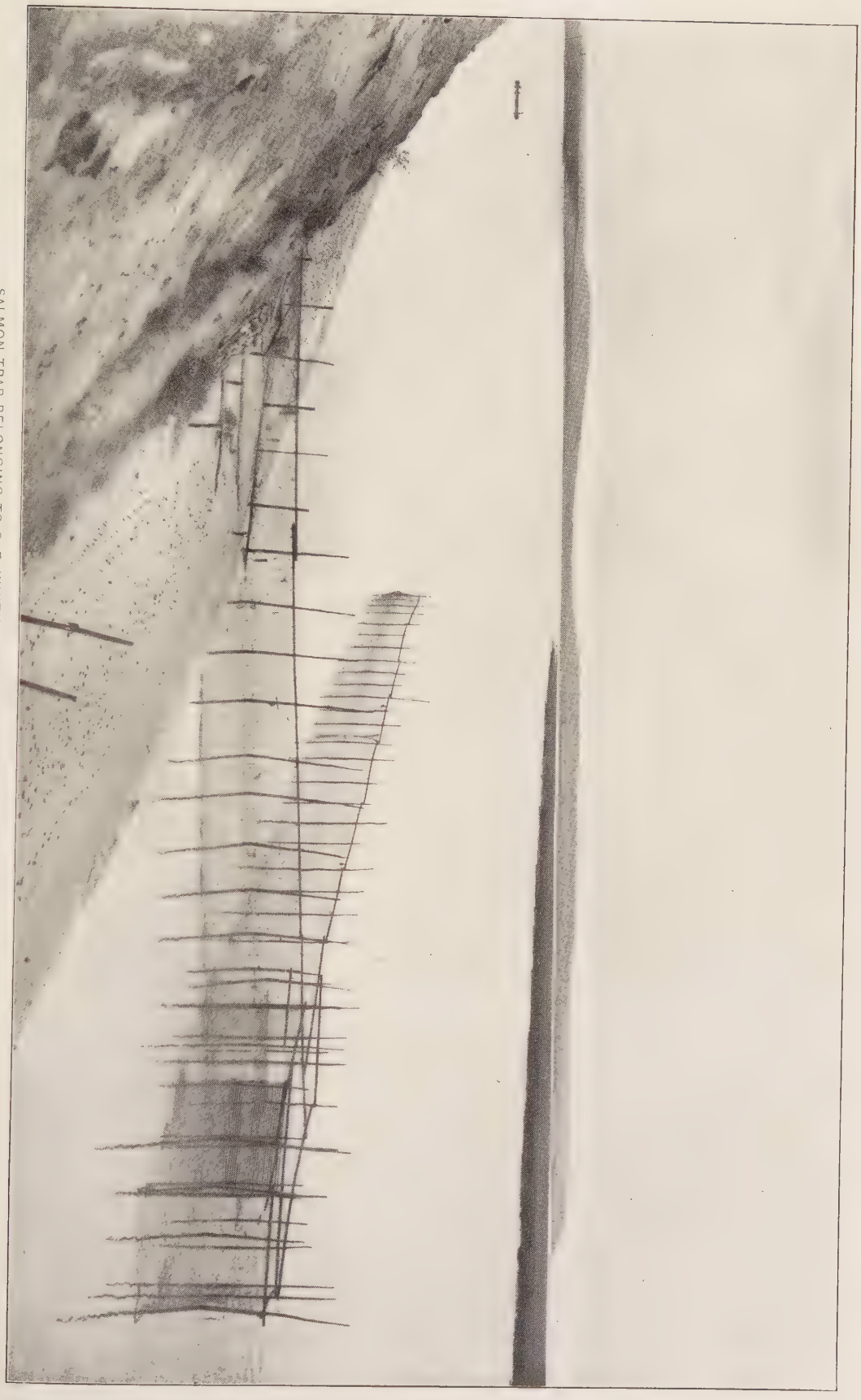
Not only is the first cost of a trap in this country large, but its maintenance forms a big item of expense. All piling must be imported, and the strong currents frequently damage both piles and web. The piles are pulled up when fishing ceases on account of the ice, and are redriven in the spring as soon as the ice is out of the river and before the fish begin to run. The largest trap seen in the Bristol Bay district had about 2,700 feet of leads laid out in a rather complex way, with two pots, 75 feet by 75 feet, and a large corral. (See sketch on page 200.)

Seines are not used in this district, largely on account of the strong current, although this could be overcome if there were good seining beaches. There are a few bowldery beaches, but, as a rule, the banks and beaches are soft mud, so that at low water landing at many points, if not impracticable, can only be effected with great effort. On one occasion, in landing at low water near a cannery on the Nushagak, we became mired to such an extent that it was only by clinging to a bidarka, pushed out to us by the natives, that we were extricated and hauled ashore.

The fishermen are white, usually foreigners, chiefly Scandinavians, with some Italians. They contract with the cannery for the season, and receive $50 per man for working the cannery ship from the home port to the cannery and back, discharging and loading the vessel at the cannery, getting the nets and boats ready, and doing other beach work until fishing begins. They receive full and excellent board and lodging from the time of leaving their home port until their return. The wages of trap and beach men are $30 per month and one-third cent per case. The gill-netters



SALMON TRAP, BELONGING TO ALASKA PACKERS ASSOCIATION, NUSHAGAK RIVER.



SALMON TRAP BELONGING TO C. E. WHITNEY & CO., NEAR THEIR SALTING STATION ON NUSHAGAK BAY.

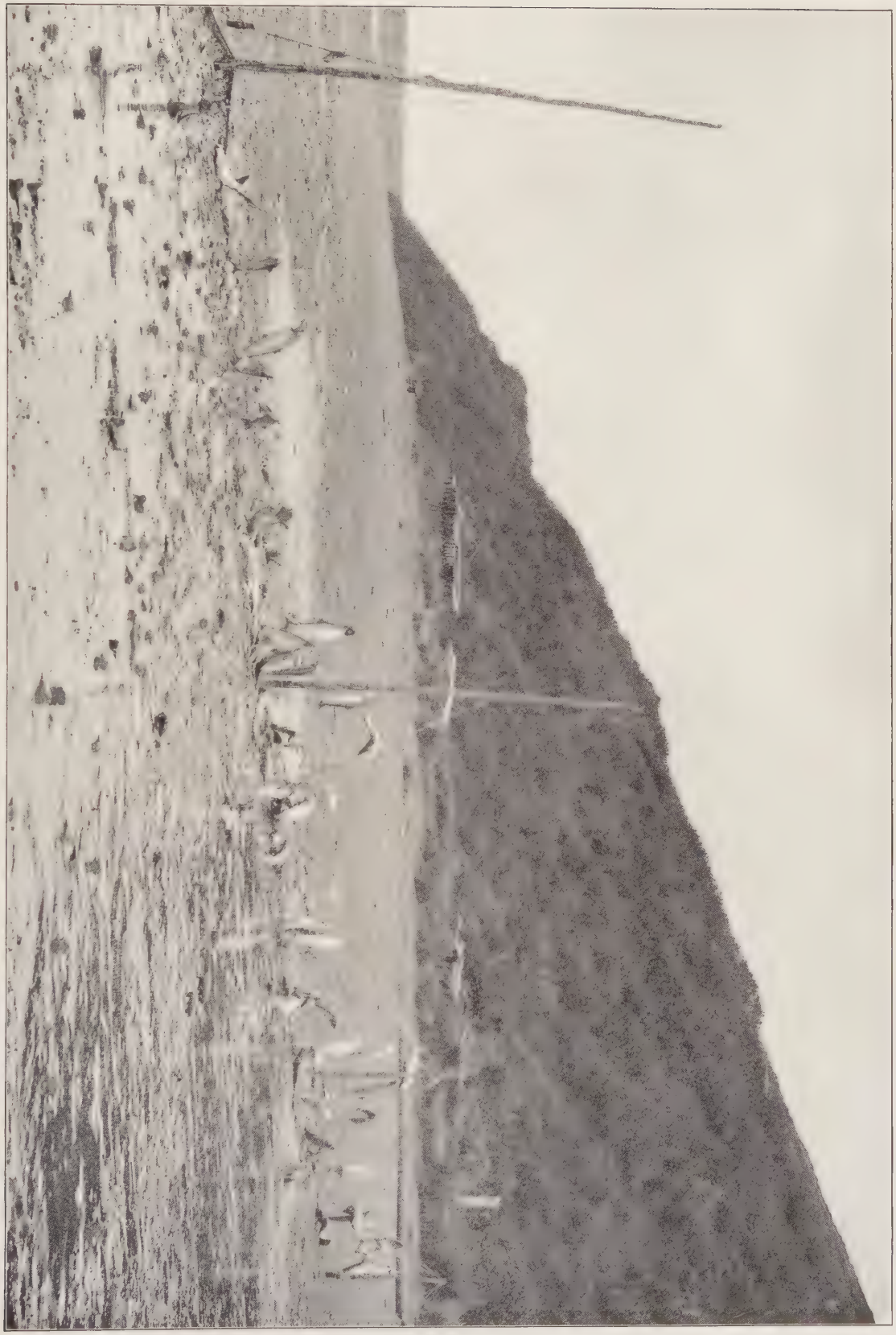
SALMON TRAP, BELONGING TO ALASKA PACKERS ASSOCIATION, ON BEACH NEAR CANNERY OF ALASKA PACKING COMPANY (A. P. A.), NUSHAGAK BAY.

NORTHERN AND INSHORE POT OF SALMON TRAP, BELONGING TO ALASKA PACKERS ASSOCIATION, NEAR GRAVEYARD POINT, KVICHAK BAY.

View from beach at low tide, showing tunnel down; steamer Sayak at anchor beyond.

SALMON TRAP, BELONGING TO ALASKA PACKERS ASSOCIATION, NEAR CANNERY OF BRISTOL PACKING COMPANY, UGASHIK RIVER.

Bull. U. S. F. C. 1901. (To face page 182.)



NATIVE METHOD OF SETTING GILL NETS, ON BEACH NEAR PACIFIC STEAM WHALING COMPANY'S CANNERY, NUSHAGAK BAY.

and boat pullers receive 2 cents for each redfish and 10 cents for each king salmon per boat of two men, the fish being delivered and tallied at the cannery or to a tender of the cannery. During a good season they average as high as $75 per month. If during the fishing season a man is taken from his boat to do other work, he receives as wages an amount equal to the average share of that day.

When the run is heavy and more fish are supplied than the cannery can use, the fishermen may be limited in their catch to 1,000 a day, but not under that amount. It is not rare, when redfish are plentiful, for industrious and expert netters, by working early and late, to make two loads, or 2,400 fish, which nets $24 to each man in the boat. This season it was noticed at three places that limits of 1,000, 1,100, and 1,200 redfish, respectively, were placed on the boats, and with the first limit at one cannery it was necessary to take some men out of the boats to clean fish, the Chinese being unable to keep up the supply for the machinery. These men, therefore, received $10 per day for butchering.

Unless one has seen the bins of a large cannery in running order words can not fully convey an impression of the masses of fish used in a single day. A thousand salmon seems to the ordinary observer a large number, yet a single three-filler cannery will utilize each day 25,000, and this district, when running full, will pack each day 250,000 in its thirteen operating canneries. It is difficult to understand how it is possible to maintain the supply, although the run is immense.

In Nushagak Bay, off Clark Point, on two occasions the fish were running so heavily that they were caught in the propeller of the launch of the *Albatross*, stopping the engines.

THE RUNS AND CANNERY WORK.

The season in Bristol Bay is short. Not only do the fish run a very limited time but good weather lasts but a few months, although the conditions are far more agreeable during the summer than over Bering Sea generally. There are many bright, sunny days, frequently quite warm, fewer gales and less fog, but with September come the gales and cold.

The cannery ships try to reach their destinations as soon as the ice will permit them to enter the bays, as there is only a short time after their arrival to make the necessary preparations before the runs begin. They expect to arrive not later than the middle of May, and to do this they must enter Bering Sea early, often encountering much ice to the eastward, though the rivers may be mostly clear. Cannery steamers (tenders) sometimes reach their destinations in April, but frequently are obliged to lie outside or to haul into a mud slough at high water and lie ashore until the rivers have discharged the floating ice.

Bristol Bay is essentially a redfish district, and while all other species occur they do not run in large numbers. They will be referred to under the cannery headings.

When the vessels arrive in May there are no salmon in the streams, even for the cannery tables. The earliest arrivals are king salmon, which appear from June 6 to 16, depending upon the river conditions. They are followed a few days later by the redfish which, about June 16 to 20, run in sufficient numbers to warrant operating the canneries for them. The king salmon run scatteringly throughout the season; but even on the Nushagak, the only Bristol Bay locality where a regular pack of this

species is made, they cease fishing for them soon after the redfish commence to run, as the latter is the more profitable fish. King salmon are nowhere abundant in this district and the few taken in the traps and redfish nets after the packing of the former species is closed are used on the cannery tables, or their bellies are salted for personal use.

It is said that there is quite a run of cohoes after the canneries have "cleaned up." A few are taken at the close of the redfish run, and it is probable that they are present in numbers until cold weather sets in.

The canneries are practically in full operation about one month, as the redfish run is over by July 20 to 25, and during this time they present a busy scene; every one is worked to his full capacity, and nothing is thought of, talked of, dreamed of, but fish. The hands of the clock are moved ahead in the morning, righted at noon, and moved back in the evening to gain time; work starts by 3 in the morning, and the bathroom is frequently not cleaned up, if it is cleaned at all, until 10 and 11 at night. The employees appear weary; the Chinese, never very robust-looking, seem to drag along as though they would drop in their tracks. The tinned fish, after cooling, are stacked in great warehouses, for there is no time to lacquer, label, and box, as the energy of the whole force is concentrated in putting fish into tin cans and sealing them. The leaky cans accumulate, as the menders can not keep up with the work, resulting in a large percentage of do-overs. At last, when the force is about exhausted, a respite comes; the run slacks and there is a sigh of relief by all except the superintendent, who swears that he has not packed enough, though every can may be filled. The relief is only temporary, however; the lacquering, labeling, testing, and boxing must now be done, and there is a rush for the final clean up, all being eager to take their departure. While the Chinese are engaged in lacquering, etc., the fishermen and the beach gangs are pulling up the traps, drying and storing the nets, hauling out the fishing boats, and loading the transport vessels. When the cargo is on board, lighters, scows, and tenders are hauled out and put under cover, the doors are closed, the watchman takes charge, and the ships sail away with the pack and the human freight.

Cannery men expect to be "cleaned up" in this district by the middle of August.

CANS IN BRISTOL BAY.

On account of the short time intervening between the arrival of the cannery ship and the beginning of the runs it is impracticable to carry the tin plate and make all the cans by hand on the working ground, according to the practice in the other districts. Until recent years all the cans were transported. At the present time 30 to 40 per cent are made at the canneries and the rest are carried from the home port. It was noticed that some of these were rusty, and upon inquiry it was learned that many were in this condition, caused probably by being packed in boxes made of green lumber.

Can-making machines are now being installed, and the latest pattern seems to work well, so that the day is not far distant when the cans will be made from day to day as they are wanted. This will effect considerable saving in labor, in storage room, and injury in handling. Besides, the machine-made can is better than the one made by hand. It has fewer defects, fewer leaks, and consequently there are fewer do-overs.

CHINESE.

An account of the Chinese cannery labor in the other Alaska salmon districts is given in the 1897 report, page 23, and it does not differ materially here.

The arrangement for the employment of Chinese is made through the labor agencies of the large cities, principally in San Francisco. They work under a "boss" of their own, who guarantees each man a certain amount for the season. They do all the work in connection with the pack. They receive the uncleaned fish at the bins and deliver them canned, lacquered, and labeled, in cases, at the other end of the cannery. The packing company transports the Chinese to the field of work and carries them to the home port at the end of the season; it provides them with a bunk house and furnishes fuel, water, and salt. The "boss" supplies the Chinese "chow," but during the height of the season they also receive some food from the white mess.

The Chinese contract this year (1900), in Bristol Bay, was 45 cents per case for machine-filled and 60 cents per case for hand-filled pack. A certain number of cases are guaranteed in the contract, which must be paid for whether packed or not, and if the pack runs over the guaranty the extras are paid for at the same rate. On the other hand, they are under contract to pack a certain number per day if the fish be on hand; and if they are unable to do so the superintendent may employ extra hands and charge them against the Chinese "boss."

These hands are usually very satisfactory, but in 1900, on account of the scarcity of labor all over our country, particularly on the west coast, an inferior class of Chinese was obtained in many canneries, and there was great complaint. At one three-filler cannery visited, and rated at 2,400 cases capacity per day, 1,900 cases was the largest number that could be made, and this number only by the greatest effort. It was noticed that the Chinese appeared weak, and many seemed ill; in fact, the sick list was large, and it required much persuasion to turn them to work in the morning. The Chinese bosses in several instances could not fill the quota with their own kind and substituted some Japanese coolies, which complicated matters materially. At one cannery, usually employing 300 Chinese, there were 250 of that nationality and 50 Japanese. These latter were not only lazy and worthless, but were constantly raising a disturbance. Of the two classes the Chinese are greatly preferred. It must be remembered, however, that the work in Bristol Bay is very trying, the season is short, the working hours are long, and the laborer is on a constant rush from the time of landing until the pack is loaded.

The most arduous work in a cannery falls upon the butchers and fish-cleaners and the bathroom men. The former are on their feet during the long hours of each day, standing in slush and gurry, and suffer much with swelled feet and ankles, while the latter are on the constant move and are the last to clean up at night. The men that work at the lye tanks, with the hot spluttering lye splashing over them, have no sinecure.

NATIVE LABOR.

The canneries gladly employ every native who is willing to work; nay, more, they seek for this labor in the villages and offer every inducement for them to work, and would employ many more if they could be obtained and were reliable. This is not done for charity's sake—the canneries are not in the field for that purpose, though

they are far from being uncharitable—but because the labor is needed, particularly when the rush is on, and for which profitable provision can not otherwise be made.

When the cannery ships arrive in the spring the native, having struggled through a long, severe winter, is hungry and has many wants. He greets the cannery ship with childish glee and wishes work. It is given him, his hunger is appeased from the overflowing cannery table, his daily wages soon supply the few luxuries he desires, and then he no longer cares for work. Why should he work? Hunger no longer worries him, his immediate wants are satisfied, and he has no others!

The condition of native labor is the same here, among the Eskimo, as it is in other sections of Alaska, to which feature reference was made in the former report;

Eskimo women cleaning salmon.

only here the canneryman, being entirely out of the lines of communication with the labor market, seems still more desirous of employing natives and frequently sends some distance to their villages to enlist them in his work. Statistics show that the largest number employed in any one cannery is from 25 to 30 for a short period. Some days there may be 40 and the next only 10.

It is true that the canneries can not give them constant employment, as their intelligence only warrants giving them certain work; still a good, reliable native will have work the greater part of the time, and can earn during the short season from $100 to $125, also having his board furnished him during the time employed.

The wages paid this year to adult males was $2 per day; reliable men received $2.25; boys from 12 to 14 years of age received $1 per day, and children were seen

piling cans who were not more than 6 years of age, and who received 50 cents a day. They demand and receive their wages daily.

Formerly the wage of adult males was $1.50 per day, but in the early part of this season a "walking delegate," in the shape of a "tyone" (chief), appeared at the canneries and the natives struck for $2 and promptly got it.

Money seems to have no value to the native except to satisfy his immediate wants, and the traders cater to their taste for gewgaws by supplying them with things for which they have no use. They have a fancy for cuckoo clocks and watches, though they can not read the time; cheap jewelry and perfume; and a silk dress is more than tempting. One woman was noticed wearing the usual skin trousers and boots, and over all a velvetine dress, well tucked up, and as greasy as if it had been soaked in a pot of rancid oil. As before mentioned, the canneries supply board to all the natives employed; the food is abundant to the point of wastefulness; it is of excellent quality, well cooked, in large variety, and given with a generous hand; none need go hungry; even the hundreds of sled dogs from the villages greet the cannery ships, gather around the canneries during the season, and grow fat, sleek, lazy, and good natured.

Of the large supplies of food carried up in the spring a considerable quantity usually remains over when the cannery closes. This is stored at some of the canneries and the watchman is instructed to distribute food in case of distress.

A large amount of salmon is cured by the natives for their own use and for the dog supply during the winter. These fish are caught with the greatest ease. A small piece of condemned gill net is obtained from a cannery and is stretched between poles planted in line from high to low water mark. When the tide falls the net is frequently so full of fish that they can not all be utilized. Nets were noticed in which it appeared as if nearly every mesh held a fish, and others were seen in which the meshed fish were decaying, the natives being too lazy to remove them in proper time. (See plate IX.)

There can be no doubt that the canneries have benefited the native by adding to his physical comfort. The fish supply for his use has not been reduced; on the contrary, the cannery has placed in the hands of the native a means for taking fish far superior to anything he ever dreamed of, and if he is willing to work he can earn money and procure civilized comforts. Whether his contact with the fishermen and Chinese during their yearly visits adds anything to his moral well-being is a question, but he suffers no more here than natives do in all parts of the world when they come in contact with our civilization.

At Nushagak a large number of tyones called on board to pay their respects to the commanding officer. In answer to an inquiry, they said they had no complaints to make and they were satisfied with the surrounding conditions.

CANNERY WASTE.

The waste in the Bristol Bay district is strikingly large, due, in the first place, to the greater abundance of fish, and, secondly, to the necessity for rushing the pack on account of the short season. To the novice who is accustomed to see fish only in a market, where salmon are sold at from 10 to 20 cents per pound, this waste is the first thing to impress him. It is probably within the limit when it is said that the

waste in this district for the present year is not under 50,000 cases of redfish alone. The waste here referred to is in marketable salmon, and does not include other fishes wasted in the traps or nets. It runs through the whole process, from the time the fish are captured until the last tapping test is made.

The largest waste probably comes from holding the fish until they are unfit to pack and then throwing them away. This may occur at the traps, in the tenders, or in the fish-bins. Many are lost in passing from fishing boat to receiving scow; others again in pewing from scow to fish-house. In this district only three cuts are made, the end pieces being thrown away; then comes the waste in machines, which, including the loss of the tail pieces, is 32 per cent greater than with a careful hand-filled pack.

The do-overs should also be considered waste, though they reach consumers in out-of-the-way places. A certain percentage is unavoidable, but in a well-conducted establishment this should not exceed 1½ per cent. In this district it is over 4 per cent.

In front of every cannery in this district, and along the beaches for several miles, thousands of dead fish are seen. Usually the tide serves well and carries other thousands away, but sometimes the wind is unfavorable and winrows of decaying fish, a hundred feet in width, along the beach, testify to the enormous waste during a canning season.

There is another source of waste that may be mentioned, which consists of the king salmon, the finest salmon that swims the Pacific waters. This species does not run abundantly anywhere in Alaska. An average of less than 8,000 cases are packed in the Bristol Bay district, of which all but a few hundred are packed on the Nushagak. They run, however, in a scattering way in all the rivers where packing is done. Very few are canned after July 1, for the entire energy is then bent upon the redfish. As a few king salmon are taken every day during the season in the traps and nets, the bellies of those not used on the cannery table are cut out and salted for private use, and the remainder of the fish is frequently thrown away. Great, beautiful fishes, weighing from 25 to 40 pounds, from which the bellies had been removed, were seen at several places lying on the beach, to be carried away by the tide or consumed by the birds.

POUNDS OF LIVE FISH TO THE CASE.

In Southeast Alaska and in Prince William Sound, where redfish are not plentiful all parts are utilized and carefully packed. Upon investigating this subject in 1897 (see report, p. 31), it was concluded that, if care were taken, from 65 to 68 pounds of live fish would make a liberal case of 48 1-pound tins, depending somewhat upon the size of the fish. In a certain locality this year conditions made it possible to make a comparison between machine-filled cans and a hand pack, and it may be of interest on account of what has been said under the subject of waste.

A small cannery that made a very careful hand pack this season by using the whole fish averaged 8.3 redfish to the case. Near by is a larger cannery making a machine pack and using fish from the same stream. By making three cuts and rejecting the tail pieces this cannery averaged 11 redfish to the case. Thirty-three redfish taken in one haul of the ship's seine averaged 8.25 pounds, and 30 redfish from the cannery bin averaged 7.5 pounds, giving a mean of 7.875. Using these factors, it will be seen that in the hand pack 65.3 pounds of fish were used to the case, the same amount as shown in my previous investigation, while in the machine pack 86.6 pounds

were used, an increase of 32.5 per cent. It should be noted, however, that in the latter the tail pieces were rejected, but were packed under a separate brand.

Inquiry made of cannerymen in the Bristol Bay district shows that it was generally conceded that it took from 80 to 85 pounds of live redfish to make a case in this district. It is my own opinion that if the waste from all sources be considered, at least 100 pounds of live redfish are used, destroyed, or wasted for every case of this species of salmon packed in this district.

INFLUENCE OF WINDS ON MOVEMENTS OF FISH.

So far as observations have been made it has been noticed that salmon in inland waters, and upon approaching them, swim at a depth estimated at from 6 to 12 feet below the surface, and that they favor a course with the wind in approaching fresh water. At Koggiung, Naknek, and Egegak the southwest winds bring an abundance of fish during the run. At Ugashik the southwest winds are best, but northwest winds also are favorable, while on the Nushagak it is claimed that south and southeast winds give the best results in the fisheries. Upon examining a chart it will be noticed that these directions of winds are over the sea and toward the several localities mentioned. As before noted, in midsummer the weather over the land in the Bristol Bay district is frequently quite warm and sunny, often too warm to keep the fish in good condition very long. It is claimed that cold weather, with light rain, gives the most favorable conditions for the successful operation of a cannery.

SALTING.

Every cannery in Bristol Bay, or, if more than one cannery in a locality is operated under one management, then every group of canneries, is fitted for salting salmon. When the fish run in such numbers that the cannery can not utilize all, the surplus goes to the salting tanks. Practically all the fish used in this manner are redfish, of which 16,778 barrels were salted in 1900 and in addition 558 barrels of king salmon.

During 1900 there was but one saltery operated solely as such in this district. It is situated on the Nushagak and had an output of 7,186 barrels of redfish and 536 barrels of king salmon for the season.

It is claimed that if salmon are dry-salted in kenches, and then boxed or barreled, they will become rusty, though this method was practiced in several instances in Southeast Alaska this year. The usual method in Alaska is to salt the fish down in wooden tanks or vats, and leave them until they are thoroughly shrunk and the water in them has been replaced by brine. They may then be washed out at any time and resalted into barrels.

It is very difficult to obtain correct salting statistics, but the following, taken from the books of the Merchants' Exchange at San Francisco, may at least show the variations in different years.

Total pack of Alaska salt salmon.

	Barrels.		Barrels.
1889	6,930	1895	14,234
1890	13,417	1896	7,700
1891	8,913	1897	15,127
1892	17,895	1898	18,718
1893	21,290	1899	22,872
1894	29,096	1900	17,687

Formerly from 46 to 47 redfish were counted as making a full barrel of 200 pounds of the salted product in this district. Inquiry at different places this season showed that the number ranged from 48 to 52 redfish to the barrel. The largest saltery averages 50 redfish, 50 cohoes, or 14 king salmon to the barrel.

For other saltery notes reference is made to my former report, page 21.

CANNERIES AND CANNERY METHODS.

In my former report this subject was fully referred to and described, and it is not my intention to indulge in useless repetition; but since my last inspection many other canneries have been visited and considerable time has been spent in observing the processing of the fish. Some new "wrinkles" have been noted which, though possibly of minor importance, may be of interest.

The general methods are quite similar in all canneries, though the arrangement of buildings and machinery, the amount of the latter, and the detailed appliances differ materially. There seems to be no standard; a cannery is built and arranged according to the individual ideas of its superintendent, and no two appear to be alike, except a few built by one company, which all seem badly arranged. It is rather surprising that some model cannery is not constructed as an object lesson.

It is not my intention to lay out a plan for a cannery, but simply to make a few suggestions and point out special features which may improve them. A cannery building should have an abundance of light, be thoroughly ventilated, well drained, whitewashed inside, and washed down with a steam hose every working day. A three-filler cannery should have a width of at least 50 feet, and the length should correspond to the machines used in processing, giving ample room, so that the cans may go uninterruptedly throughout the whole length of the building. If the ground will not admit a building long enough to have the bathroom on the extension, the the latter, with the boilers, may be located in an ell. From the door where the fish are received to the bathroom, except the mending tables, there should be nothing but the machinery and appurtenances for processing the fish. A second floor may be necessary over the filling machines for the storage of cans and for the purpose of feeding them from an elevation, but it were better to feed with a traveler and leave the roof clear for skylights and ventilation. If, however, a second floor is insisted upon, it should be double-layed, one course diagonal, to keep out infiltration of dust and dirt over the machines. A separate two-story building, parallel with the cannery, and joining it by a platform at least 40 feet wide, should be erected for a warehouse, the platform to be used for a cooling space.

The fish-house should be over the water at all stages of the tide, so that boats and lighters may discharge at any time, and the muck and gurry be carried away by the current. The other buildings, mess-houses, bunk-houses, etc., should be placed conveniently, having due regard for protection from fire.

A very convenient rigging for transferring fish from the boats to the fish-house was noticed at a cannery where there is a large rise and fall of tide, uncovering a flat in front of the building. An inclined plane led from the side of the fish-house to below the low-water mark, and a car operated by cable and steam traversed the plane. The fishing boats hauled on either side at all stages of the tide and, lying at the same

level, tallied the catch into the car, which, when full, was run to the fish-house and unloaded by dumping.

At another cannery, where fish are conveyed to the cannery by steam tenders, an inclined plane was used, extending to deep water, having the end V-shaped, admitting the cannery steamer into the V and allowing her to discharge from either side. In this case the filled cars were run over an elevation into the bins and then dumped.

In a locality where the conditions did not permit the fish-house to be located over the water at low tide, and where the cannery supply of running water was large, an immense hopper was built under the floor, with an inclined trough, through which the gurry was washed by a constant stream.

In a few canneries it was noticed that each fish-cleaning table had a spray of water from several jets playing over it, thus washing off the blood and gurry. This feature might be more extensively copied, as it promotes cleanliness in a place which is never too clean or free from odor.

At several canneries a neat and satisfactory contrivance was seen in operation for transporting fish from the fish-house to the cannery, which consisted of a shallow trough having for its bottom an endless chain of buckets. As a neat addition, a spray, formed by a perforated pipe about 8 feet long and suspended over the buckets, washed the fish while passing under it.

A new solderer was noticed, having, instead of the endless chain to give motion to the cans, a metal spiral running the length of the machine and revolving on an axle through the center. Each loop grasped a can and followed it to the end, thus giving the cans the proper motion and preventing them from rolling side by side and lapping the solder over the ends, as is frequently the case with the chain machines.

An effective contrivance was seen by which the can, after leaving the solderer, was turned upon an endless belt so as to permit the solder to set into the top, and carried upright for a distance of about 20 feet, when it was again turned on its side automatically and rolled under the cooling spray. New retorts with quick closing doors were also seen.

The Alaska Packers Association sent several fish-cleaning machines into the field for trial, but none was seen in operation. It is understood, however, that one, the invention of William Munn, the superintendent of their cannery at Alitak Bay, has been perfected after several trials, and is said to work so satisfactorily that a number are now under construction for the season of 1901. If a machine for fish-cleaning can be successfully operated it will be a great boon to the canneries.

Can-making machines are now being extensively introduced by the Alaska Packers Association, and the season of 1901 will probably see all their canneries equipped with these machines. A set consists of one cutter, which cuts the sheet tin into exact lengths for the bodies; one body-maker, which forms the body, makes the seam, and solders it; one topper and one solderer, both of which are of the same form as those used in the cannery. In the can-making department there are also dies operated by steam for cutting tops and bottoms and an extra one for cutting floats—the small piece of tin used inside the can under the top to keep the vent clear in processing. The feed for the plate in the body-maker seems to be the most imperfect part of the machine, causing frequent jams; but even allowing for delays due to these jams, a set will turn out an average of fifty cans a minute.

BRANDING SALMON.

Attempts have been made at different points on the Pacific coast to mark salmon, and it would be interesting if the facts in all cases were recorded as well as the results. It is well known that at several points young salmon have been marked by cutting off the fleshy (adipose) fin; but, unfortunately, this seems to be the only method offering any facility for marking these fishes, and if all localities adopt the same system but little benefit will be derived.

My attention has, on several occasions, been invited to so-called marked fish other than those from which the fleshy fin had been removed, and it may be of some interest to give a brief description of them. In 1897 it was called to a mark on the gill cover of a redfish at Uyak. The mark was elliptical in shape, with three-fourths inch and one-half inch as the respective major and minor axes; the edge appeared milled, and there were some blurred marks around the inner circle, while in the center there was a design which might be taken for a crown surmounting a sphere. At San Francisco, in the office of the Alaska Packers Association, a similar mark, also on the gill cover, is preserved in alcohol. This year, on the Nushagak, a mark of the same kind, though less distinct, was seen on the gill cover of a humpback. My first impression was that these marks had been made by a coin, but this would be impracticable unless made on an adult fish. It is my belief now that the mark is that of some parasite which had become firmly attached to the gill cover and left its impression. This year two redfish were taken on the Nushagak that had the dorsal-fin rays entirely removed and the skin was apparently joined smoothly over the back.

One fish was taken in the same locality with an impression resembling an M or a W, 1¾ inches square on its side; and another with the same letter, and a scroll drawn out from the end. At Koggiung two fish were taken with the M or W marks, and one with H W or M H. These marks were midway on the side of the fish, brown in color, and apparently the scales were wanting in the wake of the lines, which had the appearance of having been traced with an iron. It is doubtful if young fish can be marked in this manner, and the suggestion is offered that it is possible that the marks may have been produced by the fish lying on a piece of webbing in the bottom of the boat, and that the fish piled on top may, under proper conditions, have furnished sufficient pressure to form the marks.

OTHER SALMON STREAMS IN BERING SEA.

The question is frequently asked whether there are any streams in Bering Sea, other than those of the Bristol Bay region, which carry salmon that may be utilized for commercial purposes. To this no definite reply can be made for the reason that other factors enter into the proposition besides the one of an abundance of salmon. Accessibility is an important factor; feasibility in making a catch, length of season, and climatic conditions are others. It is customary, before building a cannery in a new locality, to thoroughly prospect it first. A saltery is often maintained for several seasons and the values of the streams ascertained. It is known that salmon of different species run in numbers in the rivers on the American side, as far north as the Noatak, which empties into Kotzebue Sound, and it is probable that other rivers emptying into the Arctic Ocean also carry salmon.

The Nushagak is the northernmost river now fished for commercial purposes; to the westward of it is the Togiak, emptying into Kulukak Bay, between Cape Constantine and Cape Newenham. The Alaska Packers Association prospected this river by maintaining a saltery near its mouth for two years, seasons of 1895 and 1896, and then abandoned it as unprofitable.

The next large river to the northward is the Kuskokwim, which, so far as known, is not accessible to vessels. The tides in this river are far greater than on the Nushagak, and the entrance is choked with banks and shoals. The census report of 1890 states, page 101:

> But a few miles to the northward of Quinhaghamiut [which is 55 miles to the northward of Goodnews Bay, according to the same report] is the present limit of navigation for seagoing crafts, at the mouth of the Kuskokwim, and even that point is reached with difficulty and at considerable risk, owing to shoals of unknown extent and shifting channels; and as at this point the anchorage is entirely exposed to prevailing winds and sea, the Kuskokwim River can scarcely be considered open to commerce. At present but one vessel a year runs in when the indications are favorable to discharge a cargo of goods sent up for the Kuskokwim trade by the Alaska Commercial Company.

The census report of 1880, in relation to salmon on the Kuskokwim, states:

> Altogether these people would be in a sorry plight indeed were it not for the abundant supply of salmon during the summer. * * * They all flock together on the banks of the Kuskokwim and fairly line the river with fish traps and drying frames, or poles, and from the beginning of June to the month of August the traps are constantly being emptied and filled again. The quantity of fish secured during the season is very great, even in proportion to the number of inhabitants, but when we consider the wasteful habit of drying the fish until only a small fraction of the original substance remains it can not astonish us to hear the natives compla'n of an insufficient supply. Over 4,000 people lay in the winter supply for themselves and for their dogs during a few months of summer, but it is safe to state that with a more economical mode of preserving the fish four times the number could live in comfort within the same space.

In the next stretch to the northward there are doubtless other rivers carrying salmon, but of these there seems to be no information, until we arrive at the Yukon, and here no exact data is obtainable. The census report of 1880 states, page 11:

> The ice came down the Yukon in such masses and in such profusion that it grounded in the deltoid mouth in the month of July so as to form a barrier against the running of the salmon.

Again, in reference to the Yukon, page 73:

> We know that the run of the various species of salmon is very large, though not extended over a large period, and also that a large proportion of the catch is preserved by the wasteful process of drying only. * * * As far as the Eskimo race has extended its settlements on the banks of the river, to a distance of from 200 to 300 miles from the sea, the fish-traps already described lie on both banks; but as the mode of fishing affects only such fish as ascend the stream along the banks and eddies, the number of salmon which complete their journey of reproduction without meeting any obstacles must exceed by far the number secured by the natives. In view of the immense width and depth of the river, it seems very doubtful whether any of this immense mass of fish could be secured by fishermen, even were they provided with all the appliances now in use on the Columbia River, in Oregon, and the Sacramento, in California.

This great river we know is not accessible to any seagoing vessel, as none but those of the shallowest draft can enter.

In reference to rivers farther north, quoting from the census report of 1880:

> Of the consumption of fish along the Arctic coast of Alaska to the northward of Bering Straits, no reliable data are accessible. The people subsist to a greater extent upon seals, walrus, and the meat of whales. The run of salmon in the few larger rivers is necessarily short, and the fish are much smaller than we find them to the southward; the natives, however, manage to put up during the brief summer a small supply of dried salmon and whitefish.

All the northern rivers probably carry large numbers of salmon, but, owing to their inaccessibility and the shortness of the season, it is doubtful if there is any locality on the American side of Bering Sea, except the Bristol Bay region, where commercial salmon fishing can be profitably conducted until salmon become very scarce. On the Asiatic side, so far as my inquiry extends, the rivers carry the same species of salmon as on the American side, and the fisheries each year are being extended. Large numbers of salmon are dry-salted on the Amur River and shipped to Japan. The Russian Seal-Skin Company, which has large concessions covering eastern Siberia, including Kamchatka, is extending its fisheries year by year. On our recent visit to Kamchatka information was obtained at Petropaulski, from their Russian manager, to the effect that they have been exporting salt salmon for the last three or four years and have now 25 fishing stations, 9 in the Sea of Okhotsk, 9 in the Bay of Avatcha, 4 on the approaches to that bay, and 3 on the outer coast in the vicinity of Cape Tschipunski. The company employs, distributed amongst these stations, 500 Japanese fishermen, who, with their sampans, nets, etc., are brought from Hakodate in the spring and returned there in the fall. The fish are dry-salted, packed in wooden crates of about 120 pounds each, and find a ready market in Japan. In 1899 the company shipped 900,000 salmon. It was the intention of this company to erect a cannery in Avatcha Bay during the year 1900, for operation in 1901.

It was stated that Kamchatka River carried an abundance of salmon of all species; but it is understood that the locality has not been prospected and the commercial value is therefore unknown. Probably all the Kamchatka rivers carry salmon.

The *Albatross* arrived in Bristol Bay July 5, making an anchorage off Cape Grey, the northern entrance point to Ugashik, but, being unable to communicate on account of unfavorable weather, we proceeded the following day to Nushagak Bay, making an anchorage off Protection Point. Expecting to obtain the services of a pilot, but no one appearing, communication was opened with the canneries, some 25 miles distant. On July 8, Mr. P. H. Johnson, the superintendent of all the Alaska Packers Association canneries on the Nushagak, came on board and kindly piloted the vessel to an anchorage in 3½ fathoms, at low water, off the cannery of the Alaska Packing Company; this is the upper cannery on the western shore, immediately below the junction of the Nushagak and Wood rivers. Here it was learned that it was impracticable to carry the *Albatross*, on account of her draft, to the canneries on the Kvichak and vicinity, and, as a cannery tender was about to leave for that section, the commanding officer and two assistants took passage on her and left that day for Kvichak Bay. In no other way could this investigation have been carried on so effectively and in so short a time, and my thanks are due to Mr. Johnson, not only for this courtesy, but for others extended to myself and the officers of this vessel.

NAVIGATION NOTES.

Until a proper survey of the Bristol Bay region has been made, it must be regarded by mariners as a dangerous locality to navigate; it is only by the greatest vigilance and constant use of the lead that disaster can be avoided upon approaching the land. This is especially true of the northern arms and approaches, which receive the waters of the great salmon streams on which all the Bering Sea canneries are located. These rivers are the Egashak, Wood, and Nushagak, emptying into Nushagak Bay; the Kvichak, Lockenuck, Naknek, and Egegak, which empty into

Kvichak Bay; and the Ugashik next to the southward of the Egegak. These rivers are large, and discharge a great quantity of water into wide indentations, locally still retaining the name of rivers, which open on the arms of the great bay. The banks of the rivers are frequently marshy, generally muddy, and the discolored water is charged with a large amount of sediment, which, when deposited, forms the dangers to be encountered.

On account of the funnel-shaped configuration, the tidal currents run with great force, having a velocity, at times, of at least 6 knots, and a rise and fall of from 18 to 24 feet; vast areas of shoals are uncovered at low water, leaving only pools and shallows, with generally narrow channels between. Navigation in the arms and approaches is only successfully accomplished at, or near, high water, even by those thoroughly acquainted with the channels.

From a point about 3 miles to the westward of Cape Grey, the *Albatross* kept along the coast, at a distance of 6 to 8 miles, for 25 miles, and then steered a course to clear the shoals off Cape Constantine. Acorn Peak was made and mistaken for Nichols Hills, but before the latter were well made out we were inside the shoals, as indicated on Coast Survey chart No. 8800, and Cape Constantine was in sight from aloft. After bringing Nichols Hills on a bearing WNW., as advised in the sailing directions, the course was laid for them and an anchorage made in 8 fathoms at low water, with Point Protection bearing SSW., distant 2½ miles. This anchorage, according to directions, is not considered a good one, and, according to the cannery people, should not be selected.

It is regretted that, as our visit to the Nushagak was for only a few days in connection with the special fishery investigation, exact directions can not be given for the navigation of these waters, but, from inquiry and my own limited experience, the following notes may be of service to others. No regular survey has yet been made of this locality. The published charts are not based upon surveys, but are compilations from all available sources, for the most part from sketches, and at best from reconnoissances, so that they should by no means be strictly followed. The mariner must regard these charts as maps and a general guide only.

"Nichols Hills," as indicated on Coast Survey chart No. 8800, and on others, is very misleading. There are no high isolated hills in the vicinity. A line of high bluffs from Egashak River border this shore to the southward, fringed by a narrow belt of marsh, and about 4 miles northwest from Protection Point these bluffs are broken on top into mounds which are the Nichols Hills, locally known as The Knolls. Under average conditions they do not afford a leading mark, as stated, for guidance from seaward, as they rise but little above the bluff line, and it is not believed they can be made out by a stranger in time to avoid the dangers off Cape Constantine.

About 2 miles northwest from Point Protection the bluffs referred to break away to the westward, and are lost on approaching the beach 2 miles south from the same point. Point Protection and its vicinity for several miles is low and marshy, with an occasional low mound and hillock. The flagstaff and pilot station no longer exist. The old Eskimo who formerly piloted the cannery vessels is dead, and a hut in ruins and a grave are all that is left to mark the former site. There are no inhabitants in the vicinity. The nearest village is Ekuk, 15 miles to the northward, on the eastern side of the bay.

The coast between Cape Constantine and Point Protection is generally low. The interior is rolling, broken into high mounds, ponds, and marshes.

Very little is known of the extent of shoal water off Cape Constantine. It is probable that the bottom is much broken and lumpy off the whole entrance to the bay. The *Albatross*, two hours before low water, had several soundings of 5 fathoms, well outside of the bay, in what is considered to be the best water.

On May 20, 1898, the Alaska Packers Association cannery ship *Sterling*, with the spring outfit for Koggiung on board, was lost on the shoals about 5 miles to the southward of Cape Constantine. At the point where the vessel struck, Cape Constantine and Point Protection are in range.

At Point Etolin there is a line of low bluffs, which at three points shows a bald yellowish face, the highest to the westward. The land in this vicinity is generally low. It is said the shoal off Point Etolin does not extend as far offshore as indicated on Coast Survey chart No. 8800. The cannery tenders in running from the Nushagak to the Kvichak usually round Point Etolin by the lead, keeping in 3 or 4 fathoms of water, which they expect to find about 4 miles from the shore.

It is my opinion that a vessel bound for the Nushagak should make Cape Grey, the northern entrance point to the Ugashik, which is high and easily recognized, and from this position take her departure and shape the course for the entrance, favoring the Etolin side in preference to the Cape Constantine side, and using the lead constantly in approaching these shoals. A vessel should arrive in the entrance of the bay midway between Point Protection and Point Etolin, and from this position a course northwest for a distance of 5 miles will carry outside the lower bar, where a stranger must anchor and communicate for a pilot. Judgment must be used in making allowance for tidal currents, and it is needless to say that the right arm of the navigator in this region is the lead.

The following notes, made upon leaving the Nushagak, may be of service. A vessel bound out should leave the upper anchorage two hours before high water, so as to have the best water on the bars. The *Albatross* left the anchorage at the upper cannery at high water and followed the western shore, at a distance of 300 or 400 yards, to the lower cannery on the same side (Bristol Bay Canning Company). After rounding the point below this cannery, the distance from shore was increased to avoid a spit making out from the first valley beyond the point, on which the bark *Wildwood* was lost. Having passed the spit, the western shore was kept well on board, making allowances for the beach that uncovers at low water. A short distance above Coffee Point the *Albatross* laid a course SSE. $\frac{5}{8}$ E. for 2.3 miles, then SE. $\frac{1}{2}$ E. for 1.1 miles, which carried over what is known as "The Cross-over" and to Clark Point. The eastern shore was then followed at a distance of one-quarter to one-half mile, and on arriving off Ekuk we hauled sharp across the river bar on a course SW. This course was kept until the cannery at Clark Point came on with the second depression in the distant blue ridge to the northward, and the right tangent of the ridge on the south side of the Egashak River came on with the left tangent of the first high mountain of the ridge beyond the low land. The course was then changed to SE. $\frac{1}{2}$ S., and after running about $3\frac{1}{2}$ miles the outer bar was crossed.

The *Albatross* made the shoal water of the outer bar on the following bearings: Clark Point, N. by W.; Nichols Hills, S. by W.; right tangent of bluff south of the

CHART OF NUSHAGAK BAY ALASKA

Acorn Peak

From a reconnaissance made in June 1890, by the Officers of the U.S. Fish Com'n Str "Albatross", Lieut. Com'd'r Z. L. Tanner, U.S. Navy, Com'd'g. With additions made in July 1900, by the Officers of the "Albatross", Commander Jeff'n F. Moser, U.S. Navy, Com'd'g.

Astronomical Stations

Cannery, Alaska Pkg. Co., 1900,	Lat. 59° 00′ 22″ N. Long. 158° 29′ 22″ W.
Clarks Point, 1890,	Lat. 58° 49′ 14″ N. Long. 158° 31′ 44″ W.
Protection Point, 1900,	Lat. 58° 27′ 46″ N. Long. 158° 42′ 19″ W.
Magnetic Variation in 1900, by Compass Declinometer	23° 20′ Easterly.

Low Mountain Ranges

Timber Line

Wood River

Low

Nushagak River

Native Village

Cannery of Alaska Packing Co

Ast. Stn

Cannery of Bristol Bay Canning Co

Native Village

Well Wooded Pt

Saltery of C. E. Whitney & Co

Cannery of Arctic Packing Co.

Carmel Village & P.O.

Moravian Mission

Fort Alexander, Nushagak Bay, Alaska

Cannery of Alaska Fishermens Packing Co

Bluff - 120 ft

Coffee Pt.

Soundings 30 to 200 feet

Clarks Pt

Reserve Cannery of Nushagak Canning Co.

Ast. Stn

Native Village.

Native Village

Inner Bar

Ekuk Pt.

Eqashak, or Snake R

Low.

Outer Bar

Etolin Point

Magnetic Variation July 1900. 23°20' East.

The Knolls. (Nichols Hills.)

Protection Pt

Ast Stn

Low

Cape Constantine

Tides.

Local Establishment, approx., 0h 53m.
Rise and Fall, approximate, 24 feet.

Scale of Nautical Miles.

0 1 2 3

Drawn by H. C. Fassett

Egashak River, W. ⅝ N. From the outer bar the cannery vessels are said to steer SE. by S. to sea. The *Albatross*, with an ebb tide, steered SE. until clear of all shoals, and then laid her sea course. On a sketch made of this locality by the *Albatross* in 1890, a few additions have been noted and the approximate track of the *Albatross* in July, 1900, has been plotted, all of which may be of service.

The following observations were made, using an artificial horizon:

Protection Point.—Latitude, 58° 27′ north, 5 sets circum-meridian altitudes. Longitude, 158° 42′ 19″ west, mean of 15 post-meridian altitudes.

Upper cannery, Alaska Packing Company, 150 yards southwest of cannery building.—Latitude, 59° 00′ 22″ north, 2 circum-meridian and 1 meridian altitude. Longitude, 158° 29′ 22″ west, mean of ante-meridian and post-meridian sights. Variation, by compass declinometer, 23° 20′ E.

From three days' observations, near neap tides, at the upper cannery, the approximate establishment is 0 h. 59 m.; approximate rise and fall, 21.55 feet. But as the former observations of the *Albatross* were probably for a longer series, that data has been retained on the chart, viz, local establishment, approximate, 0 h. 53 m.; rise and fall, approximate, 24 feet.

NUSHAGAK RIVER (TAHLEKUK).

This river, with its headwaters and tributaries, is not well known, and but little definite information could be obtained at the canneries, where it is locally referred to as the Main River. The system drains the hills and mountains between lakes Clark and Iliamna on the east and the Kuskokwim on the west. Above Kakwok, about 50 miles from the mouth, it receives a tributary from the westward which is the outlet of Lake Tikchik, and possibly a chain of lakes extending toward the Kuskokwim. This lake is by some referred to as Lake Nushagak, but the main river seems to extend to the northeast, where it has many tributaries and is known as the Mulchutna. According to the census report of 1890, page 92—

> The watershed between the Nushagak Valley and the Iliamna Basin is low and dotted with lakes and ponds, the general characteristics of these slopes being the same near the divide. * * * The whole Nushagak, or, better, Tahlekuk River Valley, including Tikchik River and Lake, is densely wooded with trees not more than a foot in diameter, which, however, increase in size as the upper courses are reached, so that on the Mulchutna and the Kokhtuli (Forest) rivers exceptionally large trees may be found in numbers.

The river on its lower course is large, and flows a great quantity of water into the head of Nushagak Bay, where it forms a junction with Wood River.

Fishing on the Nushagak is carried on entirely by traps and gill nets, and, for king salmon, commences from June 6 to 16, depending upon the season; at the large canneries fishing for this species is finished by June 30. They run scatteringly throughout the whole season, but after the redfish come in in abundance, the king-salmon gear is taken in and those found in the traps and the stray ones taken in nets are used fresh; the surplus bellies salted are for private use. The smaller canneries, however, pack the king whenever a sufficient number accumulate to make a few cases.

The redfish run in sufficient numbers to commence packing from June 16 to 20, and they are expected to run until July 20 to 25. This year the redfish run was so large that the gill-netters were limited. It is said that they supplied nearly all the fish, and of the number packed only 20 per cent were taken from traps.

Occasionally there are a large number of dog salmon, and in the early part of the season, before the redfish run strong enough to keep the full force employed, some are packed under pink-label brands. Scattering dog salmon are taken throughout the season. There is a prejudice against these fish, caused, it is believed, by the name. The sea run, in my opinion, is a very good fish, and many are consumed fresh every year, but not under that name.

At intervals of several years there is a large run of humpbacks, but so little attention is paid to this species that the date of the run is not available, but, approximately, from the middle of July to the middle of August covers the period.

Cohoes are not plentiful, and are not regularly packed. Occasionally a bunch is captured large enough to induce the canner to turn the machinery on a few hundred cases. They usually commence to run early in August, and continue after the cannery is closed, probably until after cold weather sets in.

There are no steelheads and no sturgeon. Trout are plentiful, and occasionally a shad has been taken, so it is said; sole and smelt also are taken.

WOOD RIVER AND ALEKNAGIK LAKE.

The commanding officer examined the river for a distance of 15 miles, and Lieutenant Rodman, with the steam launch, made a running sketch of the river and lake. It is from Lieutenant Rodman's notes that the following remarks are largely written, and reference is made to the sketch accompanying the report.

Wood River empties into the head of Nusnagak Bay at its junction with the Nushagak River, about 1¾ miles above the cannery of the Alaska Packing Company. The mouth is much obstructed by shoals and flats, making the entrance difficult at low water, even for small boats, without local knowledge. Its length to the lake entrance is about 24 miles; the width at the mouth is about three-fourths mile, and thence for 15 miles it varies from 600 to 200 yards; above, it narrows very much until, arriving at the lake entrance, it has a width of about 50 yards. The left bank, for a distance of about 16 miles from the mouth, is a low marshy plain, treeless until the upper part of the stretch is reached, where small clumps appear. The right bank is generally low, with bluffs bordering the stream in places, or separated from it by a belt of marsh land from one-fourth to one-half mile in width. The bluffs and the high rolling land back from the river are wooded with spruce, broken here and there by tundra flats. The banks on the upper course are high and more heavily wooded, the last 2 miles lying between steep banks from 100 to 200 feet high.

There are three low islands in the lower part of the river and one in the upper part. The first is about a mile from the mouth and is over a mile in length; the second and third are 8½ and 9½ miles respectively from the mouth, each situated in a sharp bend. In ascending, these islands are left to the eastward. The fourth is very small, about 20 miles from the mouth, and should be left to the westward.

The banks and bottom are of mud and gravel. In the upper course there are a number of sand and gravel bars, extending entirely across the channel, but it is probable that 2 feet can be carried across them at any time. For the first 15 miles the water is discolored and muddy, but above this it is usually clear, though at high-water spring tides the discoloration continues farther up. About 10 miles from the mouth it receives as a tributary the Maklau River, which is said to be about 8 miles

long. From 3 to 3½ feet can be carried up the river at low water for a distance of 15 miles, and thence to the lake not more than 2½ feet, though at high water 4 feet can be carried this distance. Local knowledge is required in its navigation at all stages of the tide, to avoid the numerous shoals and bars. The channel crosses and recrosses the river, and while the best water can usually be found on the outer course of the bends, this is not always the case.

Fifteen miles from the mouth there is a rise of tide, on the springs, of about 12 feet, at which point it is either slack or ebb current for about nine hours on each full tide, and at the lake entrance it rises about 1½ feet, but, from the size of the lake, there can be no material change in its water level due to tidal influence.

A current of about 3 knots sets out of the lake at all times and a continuous set of not less than 2 knots down the upper course. The flood current reaches a point about 18 miles from the mouth.

The head of the river flows from a shallow basin, about a mile in diameter and 1 to 2 fathoms deep, with a sandy and gravelly bottom, and at the head of this basin is a passage, several hundred yards in width, marked by low gravel tongues making out from either side, which opens upon the lake proper.

The lake is about 24 miles long, the general direction being northwest by west, and has an average width of about 2 miles.

Generally speaking, the shores are mountainous, the estimated heights ranging from 500 to 2,500 feet, those on the north, where a long flat-topped ridge parallels the shore for a distance of at least 10 miles, being the highest. The southern shore for the first 3 or 4 miles is low and rolling, with alternate open flats and woods running back several miles to the mountains. From the middle of the southern shore a narrow peninsula, about 6 miles long and 500 feet high, with a rise of 700 to 800 feet at each end, parallels the general axis of the lake and forms a deep narrow bay about three-quarters of a mile wide. The country generally is well wooded, though the mountain tops are bare.

There are many islands in the lake scattered throughout its length, mostly along the northern shore and extending to within 6 miles of the head. The large ones are well wooded, and, along the northern side, blend with the mainland, making them difficult to distinguish when seen from a point along the middle line of the lake.

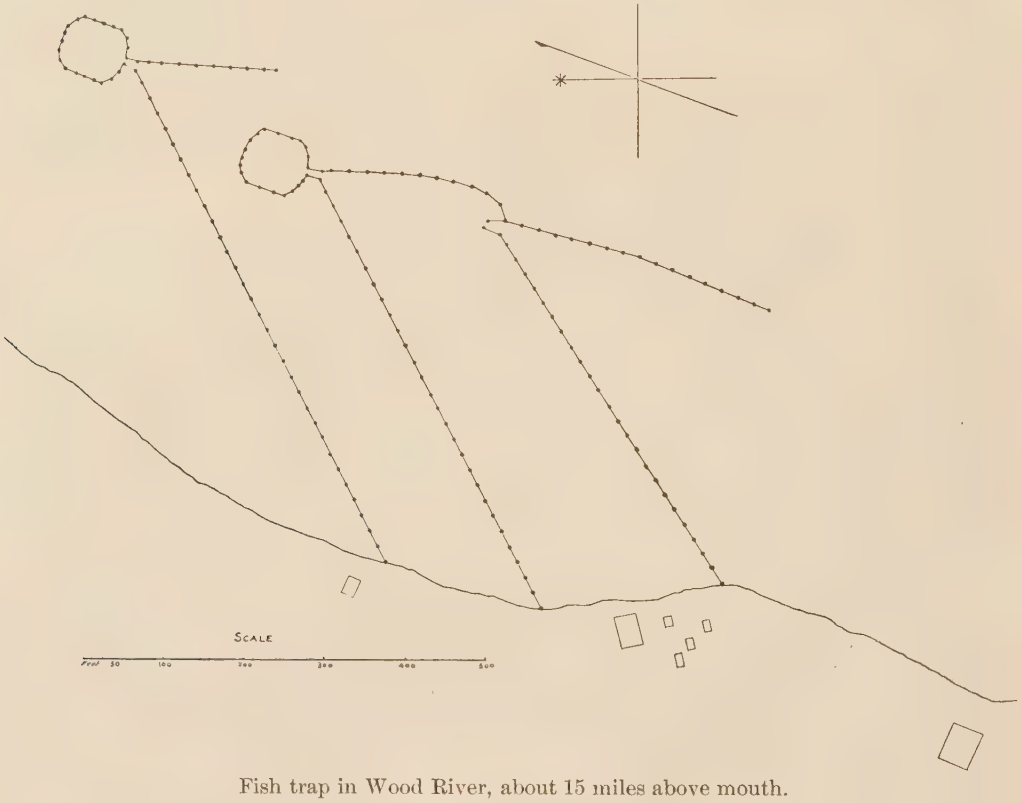
Along the center line the water appears deep; soundings were obtained in from 9 to 35 fathoms, but between some of the islands gravel bars with less than 2 feet obstructed the passage.

The water is clear; the bottom, when visible, is gravelly with small bowlders, but clean and free from grass. Gravel banks are found along the main and island shores, even bordering the rocky outcrops.

The main feeder is on the northern shore about 6 miles from the head; it is about 50 yards wide at the mouth, and 3 or 4 feet deep, and flows from the northward. It is said this stream is the outlet to two more lakes. At the head of the lake entering from the westward is a small feeder which is about 20 yards wide at the mouth and 3 feet deep. The other feeders indicated on the sketch were not visited for want of time; they were simply reported to exist, and are said to be small. Apparently the feeders flow through valleys of gentle declivity, as no falls or strong rapids were noticed, nor were any cascades seen in the mountains.

There is a village on a low sandy flat at the head of Wood River, at the northern entrance to the basin, and a second village at the mouth of the main feeder on the western shore. A large amount of salmon is taken and cured by the natives near these places and at several other points on the northern shore.

It is said that both Dolly Varden and cutthroat trout are taken on the lake. Salmon were present in very great numbers and were not only seen jumping from the surface of the lake, but, when the bottom was visible, great schools could be seen both near and away from the streams. Around the mouths of the streams they appeared in masses and a great many were noticed in Wood River ascending to the



Fish trap in Wood River, about 15 miles above mouth.

spawning-ground. In and around the feeders they had turned deep red in color, and it was particularly noticed that they seemed free from signs of injury or disease, due, doubtless, to the scarcity of obstructions in the river.

Time did not permit specific investigation relating to hatcheries, as such work would probably have to extend over quite a period in order to report with any degree of intelligence, but the general situation seems to be favorable. The basin at the outlet would make an excellent retaining-pond for ripening the fish, and, with pure water near by, two of the hatchery problems would be solved. The temperature would probably be the drawback, and some method would have to be adopted for warming the hatching water during the fall and winter.

RUNNING SKETCH OF
WOOD RIVER AND LAKE
BRISTOL BAY,
ALASKA.

By Lieut. Hugh Rodman, U.S. Navy.
U.S.F.C.S. ALBATROSS,
Com'd. Jeffn. F. Moser, U.S.N. Com'd'g.
July, 1900.

Approved:
Jeffn F. Moser.
Commander, U. S. Navy, Com'd'g.

△ Astronomic
at Cam
Latitude S
Longitude
Compass Va

PLATE XI.

Fish trap
Low flat plain
WOOD RIVER
Cannery
of the
Alaska Packing Co.
NUSHAGAK
RIVER

On the western bank of Wood River, about 15 miles from its mouth, is a trap and a trap house. This trap is the largest that was seen in the Bristol Bay district and is rather a complex arrangement. It has 2,700 feet of leads, with two hearts, 75 by 75 feet, and a corral. A description of it is rather difficult, and reference is therefore made to the sketch.

NUSHAGAK CANNERIES.

All the canneries on the Nushagak are located on the upper end of the bay, two on the western side, and four, besides a large saltery, on the eastern side; and, if one which has not been in operation since 1891 is excepted, all are within 6 miles of the mouth of the river. A brief history of the canneries was given in the report of 1897, page 173, but, as the district had not then been visited, the data was incomplete. In order to cover the whole subject in this report, it is deemed advisable to give the history anew, even at the expense of some little repetition.

On the Nushagak this year (1900) there were five operating and one reserved canneries, and one saltery, as follows: Arctic Packing Company, Nushagak Canning Company (reserved), Bristol Bay Canning Company, and the Alaska Packing Company, all belonging to the Alaska Packers Association; the Nushagak Cannery of the Pacific Steam Whaling Company, and the Alaska Fishermen's Packing Company. The saltery is known as the C. E. Whitney & Co. station.

Arctic Packing Company.—In 1883 the schooner *Neptune* was sent by Mr. Rohlfs to prospect for fish on the Nushagak, and a large number of redfish salted. The same year cannery buildings were erected for the above-named company, and in 1884 an experimental pack of 400 cases was made. This is the first cannery that operated in Bering Sea. It has made a pack every year to date, excepting 1892, when it joined the pool of the Alaska Packing Association and was closed; in 1893 it became a member of the Alaska Packers Association. The cannery is located on the eastern shore $1\frac{3}{4}$ miles above Fort Alexander, at a place called Kanulik, and known as the Mission. The Moravian mission and the village are situated on the bluff overlooking the cannery. The Nushagak post-office is also located at this point. The capacity of the cannery was increased this year and now has a daily output of 2,400 cases.

Alaska Packing Company.—This company was organized at Astoria, and in the spring of 1886 sent a cannery outfit on the schooner *Sadie F. Caller* and the brig *Courteney Foard* to the Nushagak, where a cannery was built at the head of the bay on the western side, at the village of Kanakanek (also called Chogiung) about $1\frac{1}{2}$ miles below the junction of the Wood and Nushagak rivers. It made a pack that year and every year since to date. It entered the pool of the Alaska Packing Association in 1892, and became a member of the Alaska Packers Association in 1893. The capacity was increased this year, and it now has a daily output of 2,400 cases.

Bristol Bay Canning Company was organized in San Francisco and built a cannery in 1886 on the western shore of Nushagak Bay, in a bend about 2 miles below the cannery of the Alaska Packing Company. It made a pack that year and every year to date. In 1892 it entered the pool of the Alaska Packing Association, and in 1893 became a member of the Alaska Packers Association. The capacity was increased in 1900, and it now has a daily output of 2,400 cases.

Nushagak Canning Company built a cannery on the eastern shore of Nushagak

Bay in 1888, at a place called Stagarok (also known as Clark Point), 5½ miles below Fort Alexander and 3 miles above Ekuk. It was operated in 1888, 1889, 1890, and 1891, but has not since been used. In 1892 it joined the pool of the Alaska Packing Association, and became a member of the Alaska Packers Association in 1893. This cannery is held in reserve and at present is used as a fishing station.

These four canneries are all owned and (except the reserve cannery) operated by the Alaska Packers Association, under one local management. There is a foreman at each cannery, all under the orders of one superintendent, Mr. P. H. Johnson, who resides, during the packing season, at the cannery of the Alaska Packing Company, where he is in communication with all the canneries. The greatest distance between any two in operation is 4 miles in a straight line, but on account of shoals and banks long detours are necessary in going from one to another. The association now contemplates establishing a telephone service to connect the several establishments.

The supplies are common to all the canneries of this system and are kept at the Alaska Packing Company's cannery, where there are large storehouses and considerable machinery for work in wood and metal. The fish are distributed so as to give each one a supply in order to keep all in full operation. In the statistics the pack only is kept separate. Until the present year the canneries had each a two-filler outfit, but in the spring of 1900 an additional filler was installed, and each has now a daily capacity of 2,400 cases. They all have practically the same machinery for processing the fish, which consists in each of 8 retorts, 3 fillers, 3 toppers, 2 solderers, and 1 cutter, with spare ones at headquarters to supply breaks. There are no fish-hoists or elevators; fish are pewed from boats and lighters, at low water, to platforms, and thence to fish-house, and, after cleaning, are conveyed in cars to the cutters.

About 33 per cent of the cans are made at the canneries and the rest brought from San Francisco; 100-pound domestic tin plate is used for tops and bodies. A few can-making machines were supplied in 1900, but at the time of our visit had not been set up. It is hoped eventually to make all cans at the canneries. All transportation is done by the association's own vessels, or by chartered vessels, all of which are kept moored during the season in the channels of the bay near the canneries.

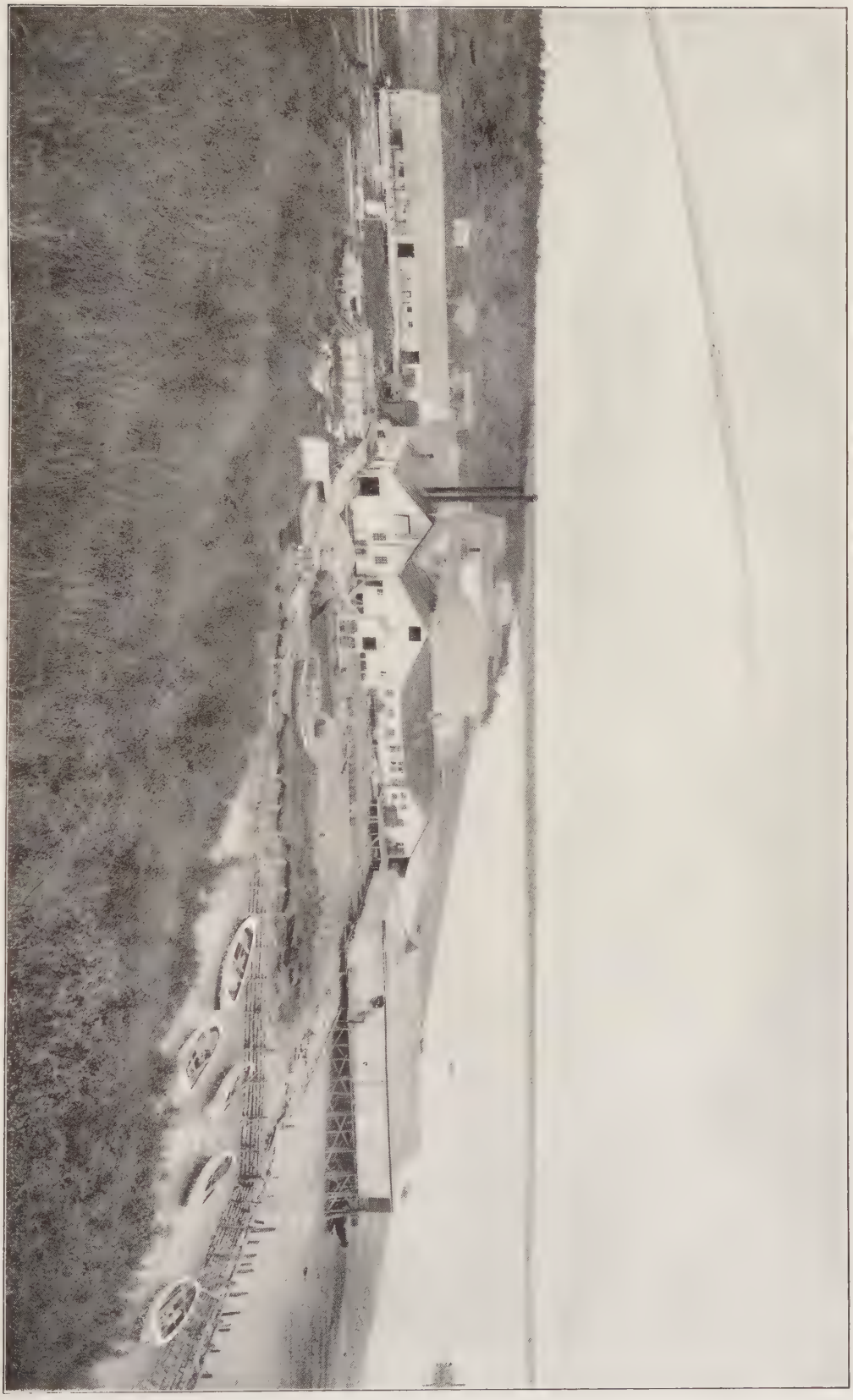
The Chinese and the fishermen's contracts, and native wages for this district, have been given on preceding pages.

The Alaska Packers Association has in its employ a physician and surgeon, who attends to the employees of the association. His office and dispensary are at the cannery of the Alaska Packing Company.

In 1900 the three operating canneries of the Alaska Packers Association employed 215 white fishermen, 66 white cannery-hands, 450 Chinese, and 75 natives. They used two sets of gill nets, 80 nets in each set, for redfish, each net 75 fathoms long, 24 meshes deep, and 6⅛-inch stretched mesh; 1½ sets of gill nets, 80 nets to each set, for king salmon, each net 125 fathoms long, 24 meshes deep, and 9¼-inch mesh; value of all about 65 cents per fathom. Besides these they had on hand a large quantity of web and material for making nets.

They used four traps—one at Clark Point, and one on the right bank of the Nushagak above the junction, each having a shore lead 500 feet long and an outside lead 350 feet long, with a square pot 40 feet by 40 feet; one trap, immediately below the cannery of the Alaska Packing Company, on Nushagak Bay, had leads 50 feet and

CANNERY OF ARCTIC PACKING COMPANY (A. P. A.), NUSHAGAK BAY.



CANNERY OF BRISTOL BAY CANNING COMPANY (A. P. A.), NUSHAGAK BAY.

View from bluff to eastward.

CANNERY OF PACIFIC STEAM WHALING COMPANY, NUSHAGAK BAY.

SALTING STATION OF C. E. WHITNEY & CO., NUSHAGAK BAY.

View from bank to northward.

ARCTIC PACKING COMPANY (A. P. A.), NAKNEK RIVER.

View of wharf, steamers, fish railroad, etc.

300 feet, pot 40 feet by 40 feet; and the large trap on Wood River which has previously been described. These traps must cost from $1,200 to $1,500 each, except the Wood River trap, which can hardly have been completed under $4,000.

The following boats were used: 18 lighters, value, $600 each; 25 skiffs, $30 each; 80 Columbia River gill-net boats, $200 each, and 2 pile-drivers, $1,200 each.

The following vessels were employed:

Class and name.	Tons.	Crew.	Value.	Owned or chartered.
Steamer Polar Bear	28	5	$12,000	Owned.
Steamer Queen	18	3	10,000	Do.
Launch Amy S	5	2	4,000	Do.
Launch Tyone	5	2	6,000	Do.
Ship Oriental	1,550	(1)	55,000	Chartered.
Ship Eclipse	1,469	(1)	35,000	Do.
Ship Tacoma	1,671	(1)	60,000	Owned.

[1] Fishermen.

The following was the output in 1900:

Species.	Alaska Packing Co.			Arctic Packing Co.			Bristol Bay Canning Co.		
	Cases.	No. to the case.	Dates.	Cases.	No. to the case.	Dates.	Cases.	No. to the case.	Dates.
King salmon	2,543	3	June 17–June 25	3,530	3	June 15–June 25	2,256	3	June 17–June 28
Redfish [1]	56,228	13	June 25–July 24	57,230	13	June 23–July 23	57,079	13	June 20–July 25
Cohoes	332	13	July 21–July 24	1,254	13	July 22–July 23	931	13	July 23–July 23
Dog salmon	1,694	13	June 19–June 27	1,921	13	June 19–June 27	2,331	13	June 23–June 27

[1] The Alaska Packing Co. also put up 1,420 barrels and 698 half barrels, averaging 50 to the barrel.

The Nushagak Cannery, of the Pacific Steam Whaling Company, is located on the eastern shore of Nushagak Bay at Fort Alexander, which is also known as Nushagak Village. The cannery outfit was transported by vessels of the company and arrived on the Nushagak April 12, 1899. The erection of the buildings was commenced at once and the cannery was ready for work June 8. A pack was made in 1899 and in 1900. It is a modern cannery, well built and equipped, has good light, and is clean and airy. The capacity is 1,600 cases per day. The cannery machinery consists of 4 large retorts (90 cases each), 2 fillers, 2 solderers, 1 topper, and 1 cutter. Fish are pewed from lighters and boats to the fish-house, and, when cleaned, are carried to the cannery by a conveyor consisting of an endless chain of buckets passing under a shower. Fifteen per cent of the cans used this year were made at the cannery, the remainder being transported. One-hundred-pound tin plate was used for tops and bodies, 20 per cent of which was imported. It is proposed to increase the capacity of the cannery to three fillers and to install can-making machinery.

The fishermen's and the Chinese' contracts and natives' wages were the same as previously noted. In 1900 the cannery employed 56 white fishermen, 10 white cannery-hands, 35 natives, and 100 Chinese.

The cannery used for redfish two sets of gill nets (25 to a set), each net, length 75 fathoms, depth 24 meshes, 6¼-inch mesh; and for king salmon two sets of nets (22 in a set), each net, length 125 fathoms, depth 24 meshes, 9¼-inch mesh; value of all, 65 cents per fathom.

The following boats were used: Six lighters, value, $300 each; 4 skiffs worth $30 each, and 25 Columbia River gill-net boats worth $200 each.

The following vessels were employed:

Class and name.	Tons.	Crew.	Value.	Owned or chartered.
Steamer Rattler	15	2	$4,500	Owned.
Bark Undaunted	1,647	(1)	60,000	Chartered.

[1] Fishermen.

The following was the output in 1900:

Species.	Cases.	No. to the case.	Dates.
King salmon	2,291	3.6	June 12–July 22.
Redfish [1]	39,223	13	June 22–July 22.
Dog salmon	1,873	13	June 20–July 1.

[1] Salted, 415 barrels redfish, 48 to the barrel.

The Alaska Fishermen's Packing Company, of Astoria, built a cannery immediately below that of the Pacific Steam Whaling Company in the spring of 1899. The canning outfit arrived May 27, and the plant was ready for operation June 25. They made a pack in 1899 and in 1900. The cannery has a daily capacity of 1,600 cases, and the following machinery is used in processing the fish: Six retorts (capacity, 47 cases each), 2 fillers, 2 toppers, 1 wiper, 2 solderers, and 1 cutter; 28 per cent of the cans were made at the cannery, using 100-pound domestic tin for bodies and tops. The fish are pewed to the fish-house and the cleaned fish then transferred by cars to the cutter.

In 1900 the cannery employed 55 white fishermen, 7 white cannery-hands, 35 natives, and 93 Chinese.

They used for redfish 30 gill nets, each 70 fathoms long, 30 meshes deep, 6¼-inch mesh; for king salmon, 25 gill nets, each 70 fathoms long, 22 meshes deep, 10-inch mesh; all valued at 75 cents per fathom.

The following boats were used: Four lighters, value, $700 each; 3 skiffs, value, $30 each; 17 Columbia River gill-net boats, value, $200 each.

The following vessels were employed:

Class and name.	Tons.	Crew.	Value.	Owned or chartered.
Steamer North Star	34	4	$15,000	Owned.
Bark Harry Morse	1,241	(1)	20,000	Chartered.

[1] Fishermen.

The output of the cannery for the year 1900 was as follows:

Species.	Cases.	No. to the case.	Dates.
King salmon	1,990	3	June 15–July 22.
Redfish [1]	38,100	12.5	June 25–July 22.

[1] Salted, 445 barrels and 105 half-barrels of redfish, 48 to the barrel.

Saltery of C. E. Whitney & Co.—This saltery was built and operated by the Bristol Bay Canning Company, on the Egashak (Snake) River in 1886; three years later three fishermen acquired each a one-quarter interest and moved the outfit to the mouth of the Nushagak. Upon the formation of the Alaska Packers Association, Messrs. C. E. Whitney & Co. purchased the one-quarter interest of the Bristol Bay Canning Company, and also that of one of the fishermen, and in 1895 purchased another quarter. In 1899 the firm became the owner of the saltery by purchasing the remaining quarter. The saltery was moved to its present site about 1892. It is the largest in Alaska and is located on the eastern shore of the Nushagak Bay, 4½ miles above Fort Alexander, at a point where the bluff recedes and the long, broad low point commences to make out to form the head of the bay.

The following are the statistics for 1900: 62 whites employed as fishermen, trapmen, saltery hands, etc., and 3 natives.

Fishing gear: One trap, near the saltery, having leads of 150 feet and 50 feet, with a pot 20 feet by 20 feet; 14 gill nets, for redfish, each 85 fathoms long, 23 meshes deep, 6¼-inch mesh; 14 gill nets, for king salmon, each 120 fathoms long, 25 meshes deep, 9¼-inch mesh.

Boats, lighters, etc.: 3 lighters, valued at $500 each; 5 skiffs, value, $30 each; 14 Columbia River boats, value, $200 each.

The following vessels were employed:

Class and name.	Tons.	Crew.	Value.	Owned or chartered.
Steamer Usok	7	2	$3,000	Owned.
Barkentine Willie R. Hume	589	(1)	25,000	Chartered.

[1] Fishermen.

The pack was completed very early on account of the large run of fish, and on July 17 the vessel was loaded and ready for sea.

The saltery output for 1900 consisted of 536 barrels of king salmon, June 14 to July 11, 14 to the barrel; 7,186 barrels of redfish, June 14 to July 11, 50 to the barrel.

The following is the output of the saltery from 1889 to date:

Year.	No of barrels.	Year.	No of barrels.
1889	250	1895	1,043
1890	400	1896	1,741
1891	700	1897	2,436
1892	1,000	1898	4,112
1893	1,400	1899	6,225
1894	650	1900	7,722

About 90 per cent of the pack consists of redfish; the remaining 10 per cent is made up of king salmon and cohoes—very few of the latter.

THE KVICHAK.

The large arm at the head of Bristol Bay, extending to the northeast and bounded on the south by a line from the southern entrance point of Egegak River to Etolin Point, has been designated in a previous paragraph as Kvichak Bay. The upper

part of the bay is very shoal, and as the current is strong it can be safely navigated only by small vessels built to resist the shock of repeated grounding. It is said that the banks from the Etolin side project halfway across the bay, and, with those from the peninsula side, confine the channel to a comparatively narrow limit. A seagoing vessel, however, under skillful guidance and with local knowledge, may reach a point a few miles below the mouth of the Naknek River, which is about 30 miles below the head of the bay; but some cannerymen, considering the risk too great to carry their transport vessels even to the mouth of the Naknek, leave them there for the season.

Above the mouth of the Naknek River the shoals begin to extend across the channel, and as a point higher up is reached the whole bay, at low water, is filled with uncovered banks having shallow, narrow channels winding through them.

At the head of the bay is the mouth of the Kvichak River, which is the outlet to the great lakes, Iliamna and Clark, lying on the western side of the mountain system bordering Cook Inlet. Very little is known of this lake region, as it has been visited by very few white men.

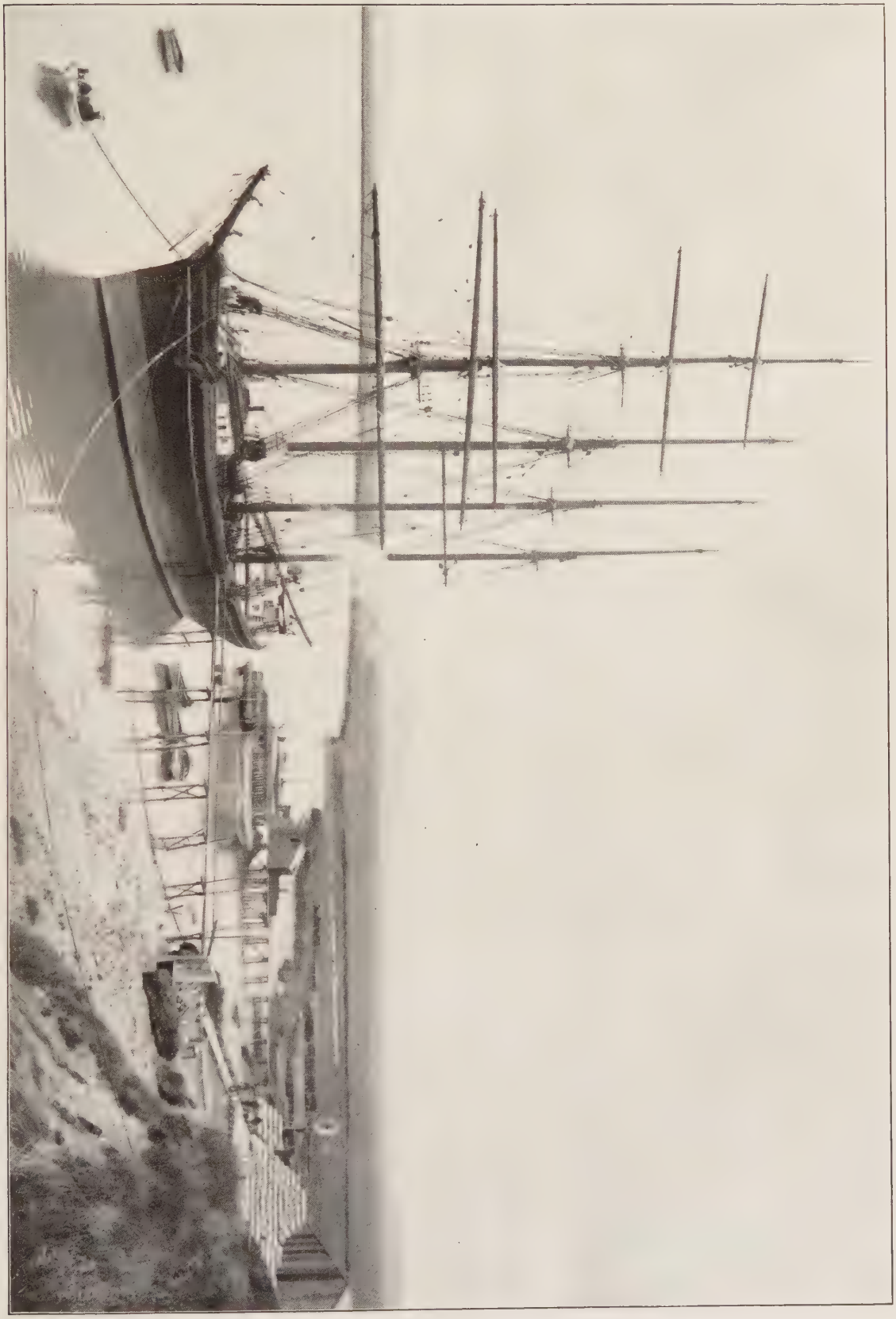
Mr. A. B. Schanz, the census enumerator of this district for 1890, and Mr. John W. Clark, of the Alaska Commercial Company, ascended the Nushagak and, taking one of the tributaries, made a portage to the Chultina, which was followed to Lake Clark. A description of the source of the Kvichak is given in the Census Report of 1890, page 92. From it the following quotation is made:

> We discovered Lake Clark on the morning of Sunday, February 15, 1891. It is a typical Alaskan mountain lake, for it has all the characteristics in a marked degree. It is very long, very narrow, very irregular, and very deep, and is surrounded on all sides by high mountains. It is nearly 70 miles long, is at the widest point hardly 10 miles wide, and is crooked and very full of bays and bights. We tried in vain, with a sounding line over 100 fathoms long, to find its bottom; and the mountains hemming it in tower in altitude from 5,000 to 12,000 feet. The general direction of the lake is northeast and southwest, and extends from the base of the Alaskan range bordering Cook Inlet to the one hundred and fifty-fifth meridian. The longitude of the geographical center of the lake is about 160° 15′ W. It has five noteworthy affluents, and its outlet, the Noghelin River, was found to be an important stream of great volume, open throughout the winter on account of its force, and running generally almost due south. The Noghelin supplies the great Lake Iliamna with its vast store of crystal water, the source of which has hitherto been absolutely unknown to geographers.
>
> Lake Iliamna is the largest lake thus far discovered in Alaska. Its greatest length is about 90 miles, and its greatest width about 40. It therefore extends over one-half the width of the peninsula, and together with its outlet, the Kvichak River, it provides a waterway from Bristol Bay to within 20 miles of Cook Inlet, and an easy portage over a mountain pass completes the route.

The river is large and discharges a great quantity of water. It is said that the influence of the tide is felt 30 miles from the mouth. The Kvichak flows into the head of the bay on the western side; on the eastern side a smaller river, the Lockenuck, having a lake source, it is said, discharges its water. At the head of the bay there is an extreme rise and fall on spring tides of over 25 feet.

The Kvichak is purely a redfish region. All the other species occur, but in a scattering way. The traps take a few trout, but no steelheads, shad, or sturgeon. The times of the runs are about the same as those given for the Nushagak. Inquiry was made regarding a hatchery site, but no information could be obtained of any location in the vicinity suitable for the purpose.

Koggiung, the location of the cannery of the Point Roberts Packing Company, is on the eastern shore at the upper end of Kvichak Bay, about 6 miles below the



SALTING STATION OF C. E WHITNEY & CO LOADING BARKENTINE WILLIE R. HUME, NUSHAGAK BAY.

mouth of the river, and, according to the chart (which is only a sketch), is in latitude 59° 01′ north; longitude 156° 56′ west.

Point Roberts Packing Company.—The Prosper Fishing and Trading Company established a saltery at Koggiung in 1894 and salted that year and in 1895. In 1896 it was sold to the Alaska Packers Association under the name of the Point Roberts Packing Company. The Alaska Packers Association established a saltery at Koggiung in 1894, near that of the Prosper Fishing and Trading Company, and after the purchase of the latter in 1896 consolidated the two. This saltery has been operated every year except 1899.

In 1895, under the same name (Point Roberts Packing Company), the Alaska Packers Association built a cannery at Koggiung, utilizing the available machinery from the cannery of the Central Alaska Company at Thin Point. It was a two-filler cannery of 1,500 cases capacity per day. It made the first pack in 1896 and a pack every year since to date. In 1897 it was enlarged to three fillers, and in 1898 a second three-filler cannery was built close to and connected with the first, so that the plant now practically consists of a six-filler cannery and a saltery.

The cannery is substantially built, light, roomy, airy, and clean. It is well equipped, and has a rated capacity of 4,800 cases per day. It has 18 retorts, of 47 cases capacity each; 4 boilers, 6 fillers, 6 toppers, 4 solderers, 2 cutters, and 5 can-makers. Fish are transferred from boats and lighters by steam hoists to the fish-house, and from the latter, when cleaned, to the cannery by a conveyor consisting of an endless chain of buckets. About 33 per cent of the cans are made at the cannery and the remainder brought from San Francisco; 100-pound tin plate is used for bodies, and 90-pound for tops; 50 per cent of the plate is imported.

The fishermen's and Chinese' contracts, and native wages, are the same as previously stated.

The Kvichak Packing Company.—Under this name the Alaska Packers Association built a cannery in the spring of 1900, on the eastern shore of Kvichak Bay, about 6 miles below the cannery of the Point Roberts Packing Company, and on the northern point of entrance to Bear Slough. It is a three-filler cannery with a daily capacity of 2,400 cases, and has substantial warehouses and quarters. It is well lighted, roomy, and well ventilated, and contains the latest machinery and cannery improvements. It was ready and commenced packing June 29.

This cannery is operated under one management with the Point Roberts Packing Company, in a manner similar to those of the association on the Nushagak. They are under the superintendency of Mr. H. C. Jansen, who has his headquarters at the former cannery, with telephone communication, so as to direct the affairs of all. The cannery machinery of the Kvichak Packing Company consists of 9 retorts of 47 cases capacity each, 3 fillers, 3 toppers, 2 solderers, and 1 cutter. Can-makers will be installed in 1901. Fish are transferred from boats by steam hoists to cars, thence to fish-house, and, when cleaned, by conveyor to cannery.

As the two Alaska Packers Association canneries are under one management the supplies, fish, etc., are common to all, and the field statistics given, except the pack, will be combined, therefore, for the two canneries.

The cannery transporting vessels—those that bring the spring outfits to Bering Sea and return with the pack in the fall—are moored in the channel in Nushagak

Bay in the vicinity of Clark Point. The transfer is made to and from the canneries by large, specially constructed steamers, drawing from 10 to 12 feet of water, heavily built and quite flat on the bottom, so that when they ground on the mud banks they may stand up when the tide leaves them, with cargo and vessel uninjured. The largest, built this year, the *Kvichak*, has a capacity of 32,000 cases, and the second, the *President*, can carry 11,000 cases.

In 1900 the Point Roberts and the Kvichak together employed 154 white fishermen, trapmen, etc., 38 white cannery-hands, 33 natives, and 447 Chinese and Japanese. The Alaska Packers Association has a physician in its employ at Koggiung, who attends the employees from Koggiung to Ugashik. There were on hand 100 gill nets for redfish—length, each, 75 fathoms; depth, 20 meshes, 6½-inch mesh; value, 65 cents per fathom. One trap, located on the eastern shore of the bay, about 12 miles below the Point Roberts cannery, had an inshore lead of 60 feet, an offshore lead of 300 feet, with a 40-foot by 40-foot pot. The offshore lead was parallel with the shore and not more than 100 feet from it; value about $1,000.

The following vessels were employed:

Name and class.	Tons.	Crew.	Value.	Owned or chartered.
Steamer Kvichak	610	13	$200,000	Owned.
Steamer Sayak	90	4	8,000	Do.
Steamer Lillian	19	3	9,000	Do.
Launch Herbert	5	2	4,000	Do.
Ship St. Nicholas	1,687	(1)	50,000	Chartered.
Ship Servia	1,736	(1)	55,000	Do.
Ship Bohemia	1,528	(1)	55,000	Owned.
Schooner (3-mast) Prosper	229	(1)	15,000	Do.

[1] Fishermen.

The boats used were: 7 lighters, worth $800 each; 6 trap-scows, $100 each; 10 skiffs, $30 each; 50 flat-bottom gill-net boats, $100 each; 2 pile-drivers, $1,200 each.

The following was the output in 1900:

Species.	Cases.	No. to the case.	Dates.
Point Roberts Packing Co.:			
Redfish [1]	99,578	12.5	June 23–July 25.
King salmon	341	3	Do.
Cohoes	297	10	July 20–July 25.
Humpbacks	1,676	19	July 15–July 25.
Kvichak Packing Co.:			
Redfish	45,200	12.5	June 28–Aug. 1.

[1] Salted: 92 barrels and 115 half-barrels of redfish, 50 trap fish, or 40 gill-net fish, to the barrel.

These canneries obtain their fish by gill nets and traps. During the 1900 season but one trap was used—that referred to on a preceding page. In 1898 and 1899 an additional trap was used in the Kvichak River, about 15 miles above the cannery. About 30 per cent of the catch is made by this means. Preparations for salting about 1,500 barrels are usually made, but very few were cured in this way during the 1900 season. It is said that, in salting, trap fish run about 50 to the barrel, while gill-net fish run about 42, which is a marked illustration of selection by gill nets.

May 20, 1898, the ship *Sterling*, with the outfit for the Koggiung cannery, was lost on the shoals off Cape Constantine. No lives were lost.

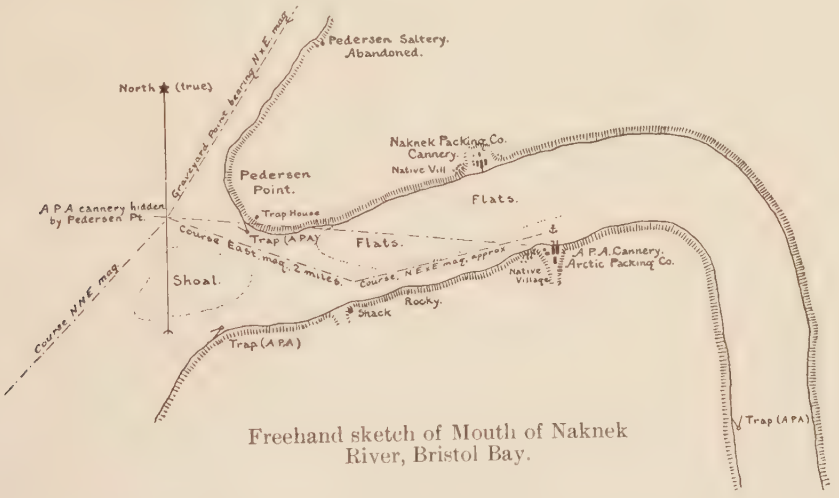
CANNING PLANT OF POINT ROBERTS PACKING COMPANY (A. P. A.), KOGGIUNG, KVICHAK BAY.

View from sand dune to southwest.

North Alaska Salmon Company.—This company, organized from the Sacramento River Packers' Association and incorporated under the laws of California, sent a large cannery plant to Bristol Bay in the spring of 1900 and built two canneries on the left bank of the Kvichak River, near the mouth, about 6 miles above Koggiung. The plant was placed in two canneries, 1,000 feet apart, for the purpose of obtaining fire protection. They will be operated, however, under one management during the season of 1901, when the first pack is expected. Each cannery will have 4 retorts, 2 fillers, 2 toppers, 2 solderers, 1 cutter, and 1 set of can-makers. As the cannery will employ 50 hands to the filler, a daily capacity is expected of 1,800 cases, or 3,600 cases for the two canneries; a conservative rating, however, would be 3,200 cases.

THE NAKNEK RIVER.

The next large salmon river is the Naknek, which enters Kvichak Bay, on the eastern side, about 25 miles to the southward of Koggiung, in latitude 58° 42′ north, longitude 157° 02′ west (approximate). The river has its source in a large lake of the same name (at one time also known as Lake Walker), on which two villages are



Freehand sketch of Mouth of Naknek River, Bristol Bay.

located. The river is large, about 60 miles in length, and flows a great body of water in a general westerly direction. It is said that tide water extends about 25 miles from the mouth, at which point the river is about one-half mile in width, and that at the mouth there is an extreme rise and fall of spring tide of over 20 feet.

Shoals and banks, many of which uncover at low water, fill the lower course of the river and extend 3 or 4 miles off the mouth, then trend around to the northward and join the body of banks that fill the upper end of Kvichak Bay. At low water the channel between the banks and the flats is very shallow; cannery steamers, drawing but 7 feet of water, await half tide before entering. Navigation is done on the rising tide or at high water.

The mouth of the river is about 3 miles wide between the headlands, which consist of bluffs about 100 feet high. Within the entrance the banks converge quite rapidly, and about 4 miles from the mouth the river is about three-fourths of a mile wide

between the banks. At this point the canneries are located, that of the Arctic Packing Company on the left bank, and nearly opposite, on the right bank, that of the Naknek Packing Company. Abreast of the cannery and for a long distance below the river bed at low water is four-fifths uncovered, and it is said that at very low water it may be forded above the cannery; nevertheless, it runs a large body of water. Very little is known of the interior. During early Russian times this lake and river formed a connecting link of the trail from Kadiak to the Nushagak, by way of Katmai.

The Naknek is essentially a redfish river, though members of all other species are present, but only in a scattering way. During the season a few king salmon and cohoes are taken. Exceptionally, there is a small run of humpbacks, but practically no dog salmon. There are a few trout, but no steelheads, shad, sturgeon, halibut, or cod.

The redfish commence running about June 14, when about 100 cases may be packed. Eight or ten days later they are running strong. July 16–20 they begin to slack, and by July 25–28 the run, for cannery purposes, is finished. In the spring very large schools of young salmon, about 4 inches in length, are seen passing out to sea. There does not appear to be any site for a hatchery in the vicinity.

Fishing is carried on entirely by gill nets and traps, which were used by both companies until this year, when the Naknek Packing Company abandoned trap fishing as too expensive to maintain.

Arctic Packing Company.—In 1890 this company built and operated a saltery on the Naknek, at a point indicated in the preceding paragraph. This saltery was sold to the Alaska Packers Association in 1893. In 1894 the association built a cannery at the same point, utilizing in its construction the available machinery of the cannery of the Thin Point Packing Company, at Thin Point, and made the first pack in 1895. A pack has been made every year since to date. The saltery has been operated every year except 1897. The original plant was a two-filler cannery, but in the spring of 1900 an additional machine was installed, and it now has a daily capacity of 2,400 cases. A pack of 55,000 cases is expected during a good average season.

The canning machinery consists of 3 fillers, 3 toppers, 2 solderers, 1 fish-cutter, and 9 retorts. Fish are transferred from boat to fish-house by cable cars running on an inclined plane and operated by steam. Can-makers have been installed, and when in thorough running order will probably make most of the cans used, though this year only 30 per cent were made on the ground, the remainder being brought from San Francisco. One-hundred-pound tin plate was used for bodies, and 90-pound plate for tops, all imported, as the pack of this cannery was for export trade.

Transportation is by the company's vessels, which in the spring approach the mouth of the river as closely as safety permits, and after discharging are moved to Nushagak Bay, where they are loaded with the pack at the end of the season.

Fishermen's and Chinese' contracts and native wages are the same as previously noted. In 1900 the cannery employed 58 white fishermen, 54 white cannery-hands, trap and beach men, and salters, 20 natives, and 140 Chinese.

The following boats were used: Eight lighters, worth $800 each; 10 skiffs, $40 each; 34 flat-bottom gill-net boats, $100 each; and 1 pile-driver, $1,200. The gill-net boats are of the same type as those used on the Kvichak, and described on page 180.

There were in use for redfish 29 gill nets, besides 47 spare ones, and sufficient

webbing for 12 more. The nets are each 75 fathoms long, 22 meshes deep, and 6½-inch mesh. King-salmon nets are not used. In addition three traps were driven, but as the netters brought in an abundance of fish only two were used. One was located on the left bank of the river, about 6 miles above the cannery, with inshore and offshore leads of 750 feet and 1,900 feet, respectively, heart 80 feet by 160 feet, and pot 40 feet by 40 feet. Another, at the northern point of entrance to the river, had leads of 750 feet and 1,100 feet, respectively, pot 40 feet by 40 feet, but no heart; and the third, of the same dimensions, which was not used, on the southern shore near the entrance. These traps are driven in the spring and pulled up when fishing ceases. They are valued at about $1,200 each. About 20 per cent of the fish used by this cannery are taken in traps.

The following vessels were employed, all owned by the company:

Class and name.	Tons.	Crew.	Value.
Steamer President	238	9	$40,000
Launch Ralph L	5	2	4,500
Launch Northern Light	4	2	3,000
Ship Indiana	1,413	(1)	50,000
Bark Merom	1,134	(1)	20,000

[1] Fishermen.

The following was the output in 1900:

Species.	Cases.	No. to the case.	Dates.
King salmon	69	6	June 18–June 24.
Redfish[1]	61,816	12.5	June 18–July 28.
Humpbacks	149	22	On July 25.

[1] Salted, 1,356 barrels and 1,141 half-barrels of redfish; 52 to the barrel.

Naknek Packing Company.—In 1890 Mr. L. A. Pedersen established and operated a small saltery on the right bank of the Naknek about 3 miles above the mouth. In 1894 a company under the above title, incorporated under the laws of the State of California, absorbed the saltery and erected a cannery near it. The first pack was made in 1895, and a pack has been made every year to date. The saltery has also been operated every year, and in 1897 an additional one was built and operated on the shore of Kvichak Bay, about 2 miles above the mouth of the Naknek. The latter was abandoned in 1900. During the present season (1900) the cannery plant was enlarged by the addition of a small cannery building, warehouse, bunk houses, etc., and it is expected to have three fillers ready for operation in 1901 and the cannery equipped for a pack of at least 40,000 cases.

The following cannery machinery is now installed: Eight retorts, 2 fillers, 3 toppers, 2 solderers, and 1 cutter. Fish are pewed from boats and lighters to fish-house. Thirty-three per cent of the cans are made at the cannery; the rest are brought from San Francisco. Can-makers have been installed, and it is expected to make a large proportion of tins at the cannery in the future. One-hundred-pound tin plate is used for bodies and 95-pound plate for tops, 50 per cent of which is imported.

The transportation was by a vessel of the company, which was kept moored in Kvichak Bay below the mouth of the river.

The fishermen's and Chinese' contracts and native wages were the same as given on previous pages for this district.

In 1900 the company employed 60 white fishermen and beach-hands, 12 white cannery-hands, 11 natives, and 131 Chinese. Twenty-one redfish gill nets were used, each 75 fathoms long, 22 meshes deep, 6¼-inch mesh; value, 65 cents per fathom.

They have 7 lighters, $600 each; 5 skiffs, $25 each; and 28 flat-bottom gill-net boats, $100 each.

The vessels employed were: Steamer *Fram*, 12 tons; crew, 3; value, $8,000; owned. Bark *B. P. Cheney*, 1,200 tons; crew, fishermen; value, $20,000; owned.

The following was the 1900 output:

Species.	Cases.	No. to the case.	Dates.
King salmon[1]	31	4, 8	Throughout the season.
Redfish[1]	35, 675	12	June 23–July 25.
Humpbacks	352	22	July 23–July 28.

[1] There were salted 22 barrels of king salmon and 1,150 barrels of redfish, the latter running 47 to the barrel.

THE EGEGAK RIVER.

This river empties into the outer limits of Kvichak Bay about 34 miles south of the Naknek, and has Cape Chichagof for its northern entrance point. It is a large river about 2 miles in width at the cannery, and is the outlet to Lake Becharof. It flows in a general westerly direction for about 50 miles. Tide water is said to extend about 25 miles up the river; very little is known of the locality.

The lower part of the river is a wide bay, contracted at the mouth, and, like other rivers of this district, at low water a large part of the bed is exposed in shoals and banks, with narrow channels winding through them. At the entrance shoal water extends several miles offshore, and the small cannery steamers enter only from half to full tide. The channel into this river is wider and deeper than in the Naknek and Kvichak, and, if it were properly buoyed, vessels of moderate draft could enter at high water; there is, however, no swinging room inside. The cannery transporting vessel, a bark of 554 tons, is carried in at high water and moored head and stern alongside of the low-water bank.

This river is also essentially a redfish stream, though all other species are found, but they are scattered throughout the season and are few in number. There are a few trout, but no steelheads, shad, sturgeon, halibut, or cod. The time of run of the redfish is the same as given under the Naknek, to which reference is made.

Egegak Fishing Station.—Under this name the Alaska Packers Association, in 1895, established and operated a saltery on the right bank of the Egegak about 5 miles from the entrance, and salted every year until 1900, when the apparatus was moved to the new cannery site, though the buildings were left standing.

Egegak Packing Company.—In 1899 the Alaska Packers Association, under this title, commenced building a cannery on the left bank of the Egegak, opposite and a little above the salting station, utilizing the available machinery of the cannery of the Baranoff Packing Company, of Redfish Bay, Southeast Alaska. This plant had been purchased during the winter of 1898 and 1899, when that locality was abandoned. The new cannery was completed in 1900, and the first pack commenced July 1. It has substantial buildings, and is clean and well arranged. The cannery

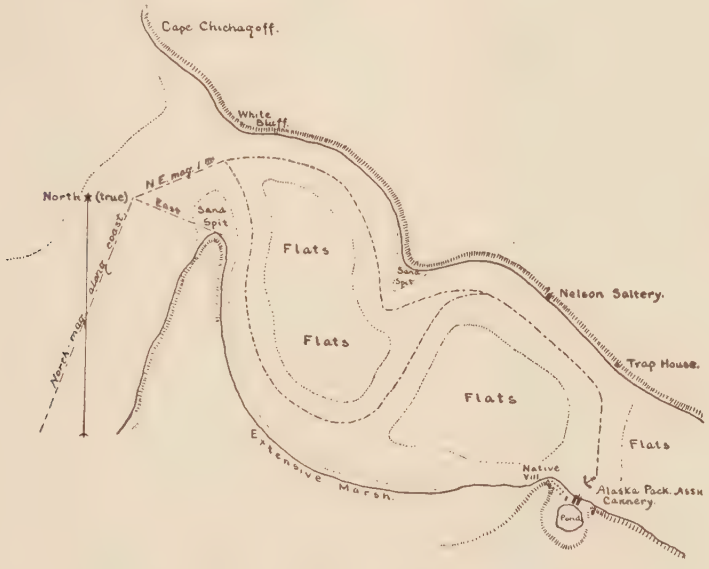
machinery consists of 5 retorts, 2 fillers, 2 toppers, 2 solderers, and 1 cutter; can-makers will be installed. This year all cans were brought from San Francisco, 100-pound tin plate being used for bodies and 95-pound plate for tops; all domestic.

Fish are pewed from boats to cars which are hauled by cable, operated by steam, over an inclined plane leading from the fish-house to the water at all stages of the tide. After cleaning, the fish are passed directly from the draining table to the cutter.

The saltery, which has been moved to the cannery site, is operated in conjunction with the cannery.

The fishermen's and Chinese contracts and native wages were the same as for other canneries of this district. In 1900 this cannery employed 39 white fishermen, 16 white cannery-hands, 10 natives, and 80 Chinese.

They used 20 gill nets, each with a length of 80 fathoms; depth, 26 meshes, 6⅛-inch mesh; value, about 65 cents per fathom. No traps were driven, but they



Freehand sketch of entrance to Egegak River, Bristol Bay.

were prepared to drive two with leads of 200 and 250 feet and pots 40 feet by 40 feet, valued at about $1,000 each.

They used 5 lighters, $200 each; 7 skiffs, $30 each; 19 flat-bottom gill-net boats $100 each, and one pile-driver, $1,500.

The following vessels were employed:

Class and name.	Tons.	Crew.	Value.	Owned or chartered.
Steamer President[1]				
Launch Llewellyn	5	2	$1,000	Owned.
Launch Corinne	5	2	2,000	Do.
Bark Charles B. Kenney	1,014	(2)	30,000	Chartered.
Bark Will W. Case	554	(2)	18,000	Owned.

[1] Employed at Naknek also, which see.

[2] Fishermen.

The following was the output in 1900: Redfish, 21,652 cases, 12.5 to the case, July 1 to July 25. Redfish, salted, 582 barrels and 1,513 half-barrels, 50 to the barrel.

THE UGASHIK RIVER.

The mouth of this river is about 40 miles below the Egegak, and, according to the chart, is in latitude 57° 38′ north, longitude 157° 48′ west; but the chart is apparently much in error. The river, it is said, has its source in a lake system of considerable extent, about 50 miles in the interior of the peninsula. In its lower course it has as tributaries King Salmon River, which enters through the left bank from the southeast about 5 miles from the pilot station, and Dog Salmon River, which enters through the left bank about 15 miles from the pilot station. These are large streams, and it is probable there are others higher up.

The Ugashik is a large river and discharges a great quantity of water into the wide indentation that has Cape Grey for its northern point and Cape Menchikoff for its southern. Cape Grey is a prominent bluff about 200 feet high, ranging several miles along the shore, brownish in color, with a few yellow vertical stripes. It appears to be the terminal point of a low ridge, which itself slopes to low land on each side. Cape Menchikoff is also a high bluff having a wider range along the shore and more hilly country back of it.

From seaward the near land visible between the capes, including the river valley, appears to be all low. The capes can be approached from the westward to within a distance of about 2 miles. The distance between them is estimated at about 20 miles, though the chart would seem to indicate the distance as about 2 miles. From the capes the low land converges to the eastward to a point where the river may be said to enter. Here it is about 6 miles across between high-water banks, and has on the northern side a bluff, 10 to 12 miles from Cape Grey, known as Smoky Point. This is recognized as the northern entrance point to the river.

The indentation formed by the two capes, the converging land, and the lower courses of the river are filled with shoals and banks. There is, however, a fair channel, through which, it is said, 9 feet may be carried at low-water spring tides. This channel is buoyed during the canning season by the Alaska Packers Association for the convenience of their vessels, but no regular system is adopted and a stranger would be unable to follow it with safety. The outer buoy is on the bar, which is nearly on a line between Cape Grey and Cape Menchikoff, 9 miles from the former. From this buoy it is about 6 miles to Smoky Point.

About 6 miles higher up the river, on a bluff on the right bank, is a native village which is called the "Pilot Station," and immediately above it, on a lower bluff, is the cannery of the Alaska Packers Association, called the Ugashik Fishing Station. It is about 17 miles from Cape Grey. An Eskimo formerly lived in the village who piloted vessels through the channel, hence the name, Pilot Station. The river is very tortuous, and winds and recurves to such an extent that at a point about 20 miles by river from the Alaska Packers Association cannery the distance across country is about 7 miles.

The Ugashik, like the rivers previously described in this report, is essentially a redfish river, and some years these salmon run in very large numbers. King salmon occur scatteringly throughout the season, and at times dog salmon are plentiful. There are practically no humpbacks, but it is said there is a run of cohoes after the canneries close. There is, at times, an abundance of trout, flounders, and crabs, but

CANNING PLANT OF ARCTIC PACKING COMPANY (A. P. A.), NAKNEK RIVER.

General view from bluff to eastward, showing headlands at entrance.

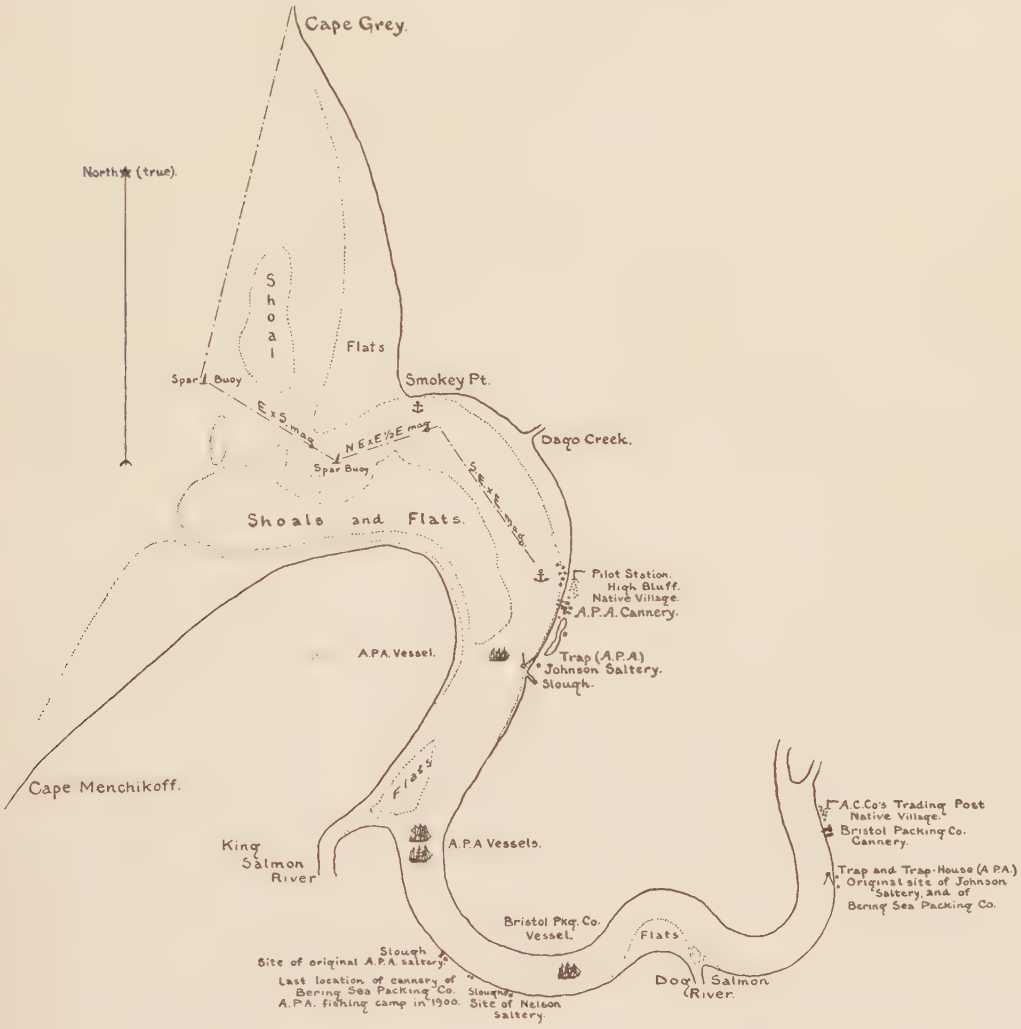
Schooner Prosper. Steamer Sayak. Steamer Kvichak.

CANNING PLANT OF POINT ROBERTS PACKING COMPANY (A. P. A.), KOGGIUNG, KVICHAK BAY.

View from stream to northeast.

no halibut, shad, or sturgeon. The runs correspond to the times given for the Naknek River.

Johnson Saltery.—Mr. C. A. Johnson salted salmon on the Ugashik from 1889 to 1898, both inclusive. He was the pioneer in this business on the river and built and operated a saltery in 1889, on the left bank, about 23 miles above Smoky Point and



Freehand sketch of Lower Ugashik River, Bristol Bay.

2 miles below the trading post of the Alaska Commercial Company. This saltery was merged in the cannery of the Bering Sea Packing company. In 1894 Mr. Johnson established and operated another saltery on the right bank of the river, about 1½ miles above the pilot station, which he sold in 1899 to the Alaska Packers Association, who absorbed it in their cannery plant.

Bering Sea Packing Company.—In 1890 this company, a branch of the Alaska Improvement Company, though a separate corporation, purchased the machinery of the Western Alaska Packing Company at Ozernoy, and commenced building a cannery on the left bank of the Ugashik, near the first Johnson saltery. In transporting the machinery on the schooner *Premier*, that vessel went ashore in Stepovak Bay and the machinery did not all reach the Ugashik until 1891, when it was installed and a small pack made that year. As the site appeared unsuitable, the cannery remained closed in 1892 and 1893, and in 1894 it was moved to a point on the left bank, about 15 miles above Smoky Point, where it was operated in 1894, 1895, and 1896. In 1897 it was sold to the Alaska Packers Association, with other property of the Alaska Improvement Company, and the machinery and equipment were utilized in the Alaska Packers Association cannery. Nothing remains but the dwelling of the superintendent, now used as a fishing camp by the Alaska Packers Association.

Nelson saltery.—In 1893 Mr. Charles Nelson established a saltery on the left bank of the Ugashik, immediately above the last site of the Bering Sea Packing Company. After operating it in 1893 and 1894 it was sold to the Alaska Packers Association and closed.

Alaska Packers Association Saltery.—In 1893 the Alaska Packers Association built a saltery on the left bank of the Ugashik, about a mile below the last site of the Bering Sea Packing Company. It was operated in 1893, 1894, and 1895, and then merged in with the Alaska Packers Association cannery, built the latter year near the pilot station.

Ugashik Fishing Station.—In 1895 the Alaska Packers Association built a cannery on the right bank of the Ugashik immediately above the pilot station, where the river is about 3 miles wide, utilizing in its construction the available machinery of the Russian-American Packing Company's cannery at Afognak. It made the first pack in 1896, and has packed every year since to date. Originally it was a two-filler cannery, but in 1900 another filler was installed, and it now has a capacity of 2,400 cases per day. The machinery consists of 7 retorts, 3 fillers, 3 toppers, 2 solderers, 1 cutter, 1 spare filler, 1 spare topper, and 2 sets of can-making machines.

Fish are pewed from boats and lighters to platforms and thence to fish-house, and when cleaned are transported in cars to the cutter. Seventy per cent of the cans are made at the cannery and the rest transported from San Francisco. One hundred pound tin plate is used for bodies and 95-pound tin for tops, all imported.

Fishermen's and Chinese' contracts and native wages were the same as mentioned under other canneries.

The transporting vessels enter the river at high water, and during the season are moored in the channel, one near the cannery and two near the left bank about 5 miles above the cannery.

In 1900 this cannery employed 64 white fishermen and trapmen, 24 white cannery and saltery hands, 20 natives, and 140 Chinese.

It used two sets of gill nets, 24 to a set, each 85 fathoms long, 26 meshes deep, 6¾-inch mesh; value, about 65 cents per fathom. There were 3 traps; one about a mile above the cannery, on the right bank, with leads each 500 feet and pot 40 by 40 feet; one about 18 miles above the cannery, on the left bank, with leads each 400 feet and pot 40 by 40 feet, and one about 22 miles above the cannery, with leads

of 600 feet and 400 feet, respectively, and pot 40 by 40 feet. These traps are valued at about $1,000 each. It is stated that about 20 per cent of the fish are taken in traps.

The following boats were used: Nine lighters, valued at $800 each; 10 skiffs, $25 each; 30 Columbia River gill-net boats, $200 each; 1 pile-driver, $1,500.

The following vessels were used:

Class and name.	Tons.	Crew.	Value.	Owned or chartered.
Steamer Thistle	56	5	$25,000	Owned.
Launch Collis	5	2	7,000	Do.
Launch Cathie K	3	2	2,500	Do.
Bark Nicolas Thayer	555	[1]	15,000	Do.
Bark Coryphene	733	[1]	15,000	Chartered.
Three-masted schooner Premier	292	[1]	15,000	Owned.

[1] Fishermen.

The following was the output in 1900: King salmon, 101 cases, 4 to the case, June 18 to June 29; redfish, 54,581 cases, 13 to the case, June 21 to July 29. There were salted 603 barrels and 606 half-barrels of redfish, 50 to the barrel, and 10 barrels of coho bellies.

Bristol Packing Company.—This company, organized largely by the stockholders of the Naknek Packing Company, sent a cannery outfit to the Ugashik early in the spring of 1900 and located on the left bank of that river about 25 miles from Smoky Point, near the site of the old trading post of the Alaska Commercial Company. The cannery was ready for packing July 9. It was not fully equipped, but had at the time of our visit 2 retorts, 1 fruit topper, 1 solderer, and 1 cutter. The work was done largely by hand, but it was estimated that 500 cases could be packed per day. All the cans were brought from San Francisco; they were made of 100-pound imported tin plate. It is said that in 1901 the cannery will be equipped with 3 fillers and the corresponding machinery, and it is anticipated that a pack of 40,000 cases will be made during the season.

The transporting vessel ascended the river to a point about 8 miles below the cannery, where she was moored in the channel for the season.

In 1900 this cannery employed 27 white fishermen and beachmen, 6 white cannery-hands, 10 natives, and 48 Chinese.

They used 8 gill nets, each 75 fathoms long, 23 meshes deep, 6½-inch mesh, valued at 65 cents per fathom. No traps were used.

The following vessels owned by the company were used: Gasoline launch *Amelia*, 5 tons; crew, 2; value, $2,000; bark *Agate*, 595 tons; crew, fishermen; value, $10,000. They have 1 lighter, value, $250; 1 skiff, $25; 7 gill-net boats, $100 each.

The output in 1900 was: Redfish, 6,653 cases, 12 to the case, July 9 to July 29. Commenced salting July 2, and salted 1,150 barrels of redfish, 46 to the barrel.

With the Ugashik our examination of the Bristol Bay district was finished. It is a wonderful salmon country, and can not be equaled. The redfish still run in countless numbers, and, as the rivers can not be barricaded and as overfishing has not yet produced its effect, there seems to be no depletion. The next few years, however, will see many new canneries established by the capital that was used in the canneries on the failing waters of the northwest coast of the United States. But in the absence of proper laws, or the enforcement of such poor ones as now obtain, these streams, too, will become depleted in time.

CHIGNIK DISTRICT.

This district was visited the latter part of July. The remarks made in my former report (pp. 164–171) on this locality hold good at the present day, and it appears unnecessary to make any changes or modifications after this second visit and examination. There have been no additions to the three operating canneries, which have packed every year to date.

The cannery men still contend that there is no diminution in the numbers of salmon taken from the river and lagoon, yet the locality no doubt is badly overfished. The lagoon and approaches and the river approaches are studded with traps, some with leads 3,500 feet long, and sometimes so interlaced that at a distance the channel appears completely blocked, and it hardly seems possible for a fish to pass. Plate IX indicates the positions of these traps at the time of our visit, and it will be seen that while 12 have but one pot, 6 have two. As the latter really consist of 2 traps joined on the leads, there were actually 24 traps, or one more than during the season of 1897, at the time of our visit.

My opinion of traps has been expressed and the waste from them referred to, but as a further illustration of this trap waste a single occurrence related to me may be given: A lighter having a capacity of 45 tons, and having nearly that amount of fish aboard, was towed to a cannery where the species desired for canning, amounting to about 6 tons, were removed; the rest, consisting of cod, tomcod, halibut, flounders, sculpins, dog salmon, trout, etc., were waste. In the spring of the year immense numbers of tomcod are taken. It is said that as much as 15 tons of this species have been thrown out of a trap in one day.

Trap men claim that the waste species are released, but such is not generally the case. If the trap be full of fish not wanted, the pot may be lowered and the fish released alive, because that is the simplest method for emptying the pot, but usually all are dipped out together and the sorting is done afterwards.

If traps be prohibited—and in my opinion they should be—it is difficult to say what the fishing results will be at Chignik. At present traps, gill nets, and seines are used, and the catch is represented in the following proportions: Traps, 70 to 75 per cent; gill nets, 20 to 25 per cent; and seines, about 5 per cent. It is believed that an honest effort has been made with gill nets and seines, but the results have been very unsatisfactory. For gill-net fishing the water is too clear and the channels too shallow and narrow. For seining there are no beaches and the bottom is unsuitable. However, if the fish are there the cannerymen will devise some means for obtaining them. A few years ago purse seines were tried in southeastern Alaska and pronounced a failure; now they are very generally used in certain localities, and with such success that the boast is made that they need no longer construct barricades, as they take with purse seines all the fish that come to the streams.

The times of the runs of the fish are given in my former report (page 169), to which may be added that some years there is a small run of humpbacks and usually a great many dog salmon. Steelheads rarely occur. Dolly Varden trout are numerous and arrive a few days before the redfish, remaining until late in the fall.

The Chinese contract at Chignik varied this year from 42 cents to 42½ cents per case, on guaranties of 20,000 to 28,000 cases, with the usual conditions.

Pinnacle Rock
Sand Spit
Seining Ground
Gill-Net Ground
Seining Ground
Seining Ground
Grass Flat
(Uncovers at Half Tide)
Grass Flat.
(600 Ft. approx.)

CHIGNIK LAGOON,
CHIGNIK BAY, WESTERN ALASKA.

U.S.F.C. Sᵗᵉ "ALBATROSS",
Commander Jeff.F.Moser, U.S.N., Com'd'g.
July 1900.

Locations of Traps, July 28, 1900

Note
.....Edge of flats at low-water.

R Salmon Trap.
Traps of Alaska Packers Association marked "A"
" " Pacific Steam Whaling Company " "W"
" " Hume Brothers and Hume " "H"

Approved:
Jeffn F. Moser.
Commander, U.S. Navy, Com'd'g.

The fishermen's contract varied in the different canneries. In one, all fishermen and trapmen were paid $30 per month, with full board, from the time of signing in San Francisco until paid off on return, and one-fourth cent per case. In two other canneries the same contract as the preceding was made with the trapmen, except that their pay ceased on leaving Chignik, for the reason that they were not obliged to work the vessel. In these two canneries the gill-netters were differently paid. In one they received $15 per month, without board, from the day of arrival until the day of departure, 3 cents per fish to be divided among all netters, and 35 cents per day for commutation of ration. In the other cannery gill-netters had $20 per month from the date of arrival to that of departure, full board, and 3 cents per fish.

We spent a Saturday in the lagoon. One cannery packed a few fish in the morning, left from the preceding day, and was then closed. The tunnels of the traps of this cannery were all up, so far as could be seen, and upon inquiry it was reported that they had strict orders to obey the weekly close season, and were doing so. Several scow-loads of fish, however, were noticed during the afternoon on their way out, and the web of a number of traps was noticed down.

For a history of the canneries, with their locations, etc., see my former report.

The Chignik Bay Company has a daily capacity of 1,600 cases, and operates in its cannery 7 retorts, 2 fillers, 2 toppers, 2 solderers, and 1 cutter. It has two sets of can-makers, with a capacity of 70,000 cans per day, and all the tins are made at the cannery, largely of imported material, using 100-pound plate for the bodies and 95-pound plate for the tops. The fish are pewed from boats and lighters to the fish-house, and the cleaned fish are conveyed by car to the cannery. It employed in 1900 63 white fishermen, 13 white beachmen, 3 white coal-miners, 4 white cannery-hands, 2 natives, and 90 Chinese. They used 1 gill net, but have 10, each 135 fathoms long, 30 meshes deep, 6½-inch mesh, value 65 cents per fathom; 3 drag seines, but have 4, from 75 to 180 fathoms long, 3 to 3½ inch mesh, 120 to 180 meshes deep at bunt, value $1.50 per fathom; 6 traps of 1 pot and 2 traps of 2 pots, shore leads varying from 150 to 3,500 feet, average 1,000 feet; channel leads, 100 to 1,600 feet, average 900 feet; hearts 75 feet across, and pots 40 feet by 40 feet, average value $1,500 each. The trap web is all tanned, pots 54-thread, wings 36-thread; the piles are 10 feet apart.

The following boats were used: Two schooner-rigged lighters, capacity 11,000 fish, value $1,500 each; 1 sloop-rigged lighter, capacity 4,000 fish, value $750; 12 trap scows, capacity 1,800 to 3,500 fish, average value $250; 3 flat-bottom seine boats, $100 each; 15 skiffs, $25 each; 7 Columbia River boats, $200 each; 8 flat-bottom gill-net boats, $100 each; 3 pile-drivers, $750 each.

The following vessels owned by the company were employed:

Class and name.	Tons.	Crew.	Value.
Steamer Afognak	37	5	$18,000
Steamer Baby Ruth	10	4	5,000
Ship George Skolfield	1,275	(1)	20,000

[1] Fishermen.

The following was the ouput in 1900: Redfish, 40,334 cases, 10.5 to the case, June 10 to August 12; cohoes, 62 cases, 10 to the case, August 3 to August 12.

The *Pacific Steam Whaling Company's cannery* at Chignik, located in Anchorage Bay, operated this year in its canning plant 2 iron retorts, 4 steam boxes, 1 filler, 1 solderer, and 1 cutter. The fish are pewed from lighters to the fish-house, and after cleaning carried by cars to the cannery. The plant has a daily capacity of 950 cases, and they expect to pack during the season about 30,000 cases. It has no can-makers. The cans are all made by hand at the cannery, using 100-pound tin for tops and bodies, of which about 13 per cent is imported. The plant will probably be enlarged.

In 1900 this cannery employed 60 white fishermen and trapmen, 10 white cannery-hands, 4 natives, and 60 Chinese. They used 10 gill nets, each 260 fathoms long, 30 meshes deep, 6-inch mesh, valued at 65 cents per fathom; 3 seines, 2 of 200 fathoms length and 1 of 300 fathoms length, each 22 feet deep, 3-inch mesh, valued at $1.50 per fathom; 4 traps (2 single pot, 2 double pot), average shore lead 800 feet, average channel lead 800 feet, heart 80 feet each side, and pot 40 feet by 40 feet, average value $1,500 each.

The boats used were: Four lighters, $400 each; 2 sail scows, value $200 and $800; 10 trap scows, $60 each; 10 skiffs, $25 each; 3 seine boats, $75 each; 3 gill-net skiffs, $100 each, and 3 pile-drivers, $1,000 each.

The vessels employed were: Steamer *C. C. Cherry*, 37 tons, crew 6, value $15,000, owned; launch *Esquimaux*, 5 tons, crew 2, value $2,500, owned.

Transport of pack and spring outfit by calling vessels of company.

The following was the output in 1900: Redfish, 32,966 cases, 11.4 to the case, June 9 to August 6; dog salmon, 120 cases, 10 to the case, July 20 to July 28. Salted 69 barrels of humpback bellies, 450 to the barrel.

Hume Bros. & Hume cannery at Chignik, located at Anchorage Bay, operated this year in its cannery plant 4 retorts, 1 filler, and 1 solderer. The fish are handled from lighters to cannery in the same manner as noted under other canneries. The plant has a capacity of 800 cases per day, and they expect to make a season pack of 25,000 cases. Cans are made by hand, of 100-pound tin for tops and bodies, of which 50 per cent is imported.

In 1900 this cannery employed 52 white fishermen, 10 white cannery-hands, 6 natives, and 58 Chinese. They used 15 gill nets, each 150 fathoms long, 26 meshes deep for lagoon and 40 meshes deep for outside fishing, 6-inch mesh, value 65 cents per fathom; 2 seines, 150 fathoms long, 25 feet deep at bunt, 3-inch mesh, value $1.50 per fathom; 7 traps (5 single, 2 double), average shore and channel leads 800 feet, heart 80 feet on each side, pot 40 feet by 40 feet, average value $1,500.

The boats used were 13 lighters, $140 each; 2 sail scows, $300 and $600; 14 skiffs, $25 each; 2 seine boats, $70 each; 8 Columbia River boats, $200 each; 10 gill-net skiffs, $100 each; 2-pile drivers, $1,050 each.

The following vessels (owned by the company) were employed:

Class and name.	Tons.	Crew.	Value.
Launch Florence Hume	5	2	$3,200
Launch Ethel and Marian	6	3	2,880
Bark Ferris S. Thompson	480	11	12,000
Schooner Maid of Orleans	171	8	8,000

The following was the output in 1900: Redfish, 23,003 cases, 11 to the case, June 6 to August 19; dog salmon and humpbacks, 3,614 cases, 10 to 21 to case, July 2 to August 19.

ALITAK BAY, KADIAK ISLAND.

On Olga Bay, and its connecting waters with Alitak Bay, locally known as the "South End," there are one operating and one reserve canneries and several excellent salmon streams. As the locality was not visited in 1897, and as the whole region is unsurveyed, the *Albatross* this season, whilst engaged in the salmon investigation, made a sextant reconnoissance of a portion of these waters. The area is so large that the five days allotted to the work were not sufficient to cover more than the anchorages and the passages leading to them. The results, however, should be of great service to vessels navigating these waters. In the following notes reference is made to the drawing of the reconnoissance accompanying this report.

Alitak Bay is a large body of water on the southwestern side of Kadiak Island, about 65 miles by sea from Karluk. The entrance, from Cape Alitak on the west to Cape Trinity on the east, is about 8 miles wide, and in its length of 14 miles the bay narrows to 5 miles at the upper end, where it terminates in two wide arms, each several miles in length. The general direction of the bay is NNE. and SSW. The western side has several indentations, with islands, rocks, and foul ground for a distance of 2 miles off the middle section. At the northern end of this section, about 11 miles from Cape Alitak, a passage extends westward around the upper islands and opens upon a broad sheet of water, named Moser Bay, which, in a distance of 3 miles, turns to the northward the same distance, where a narrow gut leads to Olga Bay.

In approaching Alitak Bay from the northward Low Cape is first made about 9 miles from the western point of entrance. The former is a low bluff, and the shore line, which is low with high mountains in the background, extends to the latter in a deep bend, making to the northward and eastward.

Cape Alitak is the terminal point of an undulating granite ridge, named Tanner Head, about 4 miles in length, the northern end bordering on Lazy Bay. This ridge is a peninsula, with the highest hills (about 600 feet) at the northern and middle parts, from which there is a gradual roll and descent to the pitch of the cape; this, at the extreme point, is low and rocky. In approaching from the westward it is seen as a long point with rolling hills and knobs gradually shelving to the sea.

Five miles to the northward from Cape Alitak the western shore makes out in a high head, named Drake Head, which separates Lazy Bay from Kempff Bay. Surmounting the head are two conical peaks, Twin Peaks, about 1,200 feet high, which, in clear weather, can be seen a long distance from seaward. They are easily recognized, and make an excellent guide to the entrance.

South of Drake Head is Lazy Bay, which may be recognized from its position with reference to the Twin Peaks and Egg Island, the latter a small rocky islet lying just north of the entrance. From this bay a narrow arm, named Rodman Reach, projects to the southwest inside of Tanner Head to Cape Alitak, where it forms a basin from which another narrow arm extends for some distance to the northwest, being separated from the sea by but a narrow strip of land. Lazy Bay affords good anchorage and is very accessible.

Kempff Bay, northward of Drake Head, is about 1½ miles long by 0.4 mile wide, and is apparently clear of dangers. For want of time, no soundings were made, but if upon examination proper depths are found, it should make an excellent harbor.

From Drake Head to the passage leading to Moser Bay are a number of islands, rocks, and ledges making off from the western shore. Inside of these is Akhiok,

a native village, which, in 1890, contained over 100 inhabitants. The people here suffered severely during the last winter (1899–1900), many dying with a disease never properly diagnosed, but which was probably grip.

The peninsula separating the North Arm of Alitak Bay from Moser Bay is a high ridge shelving toward the southern end, and has been used by the cannnery steamers

as a leading mark. High Rock is a high, detached rock, easily recognized on approaching the passage, with rocks and submerged reefs, covered in summer by kelp, extending nearly two-fifths mile off the southern and eastern sides.

The eastern shore of Alitak Bay consists of high, bold bluffs, terminating in Cape Trinity, which, from a distance, appears bold, and on the continuation of the general line of the bluffs. This shore was not closely examined, and, while no dangers were seen, it should be approached with caution. Near the middle of the bay, 10 miles within the entrance point, is an extensive ledge named Middle Reef, covered at high water, but baring over a considerable area at low water.

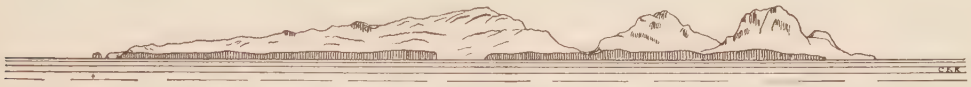
In the extreme western end of Moser Bay is Snug Harbor, and 2 miles to the northward is Chips Cove, both affording excellent anchorage.

The peninsula formed by Olga and Alitak bays and the connecting waters is treeless. It is broken up by mountain masses rising to a height of about 2,000 feet, rolling tundra, marshes, and lakes.

The sextant reconnoissance extends only to the Narrows connecting Moser Bay with Olga Bay. The plan of the latter is from a running sketch made in the steam launch, checked by a few cuts made upon mountain peaks.

SAILING DIRECTIONS.

In entering Alitak Bay, after making the Twin Peaks, shape the course to arrive off the entrance with Cape Alitak bearing NW. distant $2\frac{1}{2}$ miles; then lay a course N. by E. $\frac{3}{4}$ E., and run 8.4 miles. This should bring a ledge, that is said to cover only at high water spring tides, on the port beam distant 1 mile; then change course to N. $\frac{1}{4}$ W. bringing High Rock ahead, and run 3 miles, when the passage to Moser Bay should be wide open. Now follow the chart, keeping in mid-channel, favoring the northern shore for the deepest water, and, when well inside, keep in the middle of Moser Bay; if bound for Snug Harbor, open it fair, steer for the center, and anchor with the lead. Do not approach the head too closely, as the flats make off some distance from the reserve cannery building. If bound for Chips Cove, keep in mid-channel and anchor by the lead. The only danger known in Moser Bay is a shoal, or reef, lying 1 mile to the eastward of Point Fassett and one-fourth mile off shore, and a spit making off a short distance from the middle point of the southern shore.



Cape Alitak, bearing SW. $\frac{1}{4}$ W., mag., distant $4\frac{1}{2}$ miles.

The bottom, in the passage, is much broken; immediately inside $3\frac{1}{2}$ fathoms were found in mid-channel at low water. It should be remembered that the work of the *Albatross* was only a sextant reconnoissance and not a detailed survey, so that every precaution should be observed in entering. It may be remarked here that the dangers are usually marked by kelp in summer, but this is not always the case.

Lazy Bay.—The Twin Peaks and Egg Island are the guides to Lazy Bay. No hidden dangers were found. With the bay wide open enter in mid-channel on a west course, and anchor at discretion.

Time did not permit sounding inside of Rodman Reach, but from all appearances it may be entered far enough to obtain shelter from all winds. The first projecting point has a spit extending from it.

It is said that a 5-fathom ridge, or bar, extends from Cape Alitak to Cape Trinity, and that kelp has been seen in places on it. The *Albatross* on entering encountered the shoal soundings at this point, and also on leaving, as shown on the chart. The shoals off the southwest end of Tugidak Island are said to run in ridges.

The Narrows.—About 1 mile to the northward of Chips Cove is the southern entrance to the Narrows which lead to Olga Bay. They are about 1 mile in length and in the narrowest part about 300 feet in width. The channel is tortuous with many rocks, some of which uncover at low water, and others which are only apparent by the heavy swirls over them when the current is running full. The small cannery steamers use the Narrows, but local knowledge is necessary and a large vessel should not attempt the passage. With the current running full the cannery steamers wait for slack water, which occurs two hours after high and low water at Snug Harbor. The current at its greatest velocity probably reaches 8 knots. It is said that $3\frac{1}{2}$ fathoms can be carried through the channel at low water, but this statement should be received with caution.

Observations with sextant and artificial horizon for geographical position were obtained at the northern entrance to Snug Harbor, which gave latitude 56° 59′ 26″ north, longitude 154° 12′ 22″ west. Variation by compass declinometer 29° 17′ east. Establishment from 8 successive high waters, at moon's age from five to nine days: $XI^h\ 38^m$. Mean rise and fall of tide during same period, 6.71 feet.

Olga Bay is an irregular-shaped body of water lying in a general east-and-west direction, rather crescentic in form, with the cusps to the southward; it is from 17 to 18 miles in length, with a width of from one-half mile to 2 miles. The western end is the largest and is separated from the sea about 6 miles to the northward of Low Cape by a strip of low land only three-fourths of a mile wide. The bay has the appearance of a lake, and having such a narrow passage to the sea the tidal influence is not very great, the rise and fall varying from 1 to 2 feet at the cannery.

OLGA BAY CANNERIES.

The only operating cannery in this section is located on the northern shore of Olga Bay, about 10 miles from the northern end of the Narrows. The history was given from incomplete data in my report of 1897, but as some additional information has become available, it is rewritten here.

Arctic Packing Company.—In 1889 this company built a cannery in the southwestern end of Olga Bay, at the mouth of a small stream on the eastern shore known as the South Olga Fishing Station. The cannery was not well equipped, and the capacity was only from 250 to 300 cases per day. As the location was not favorable it was moved the following year across the bay to a point 8 miles to the northward, on the right bank and near the mouth of a small stream known as the North Olga Fishing Station, which is its present position. The change of location was very satisfactory, and the cannery was much improved in equipment, buildings, etc.

In 1891, under an agreement with the Kodiak Packing Company, in the same locality, the cannery of the latter was closed and its quota of fish was packed in the Arctic cannery. In 1892 it was in the pool formed by the Alaska Packing Association,

To OLGA BAY, only for small vessels with local knowledge

Scale of Miles

High Rolling Plain

Chiga Cove

Sandspit

Point Fussett

Ast. st.

K.P.Co. Cannery

Snug Harbor

High Rock

Low Land

Miller Isd

Ahkiok Village

Sunken Reef

Round Hill Island

Pryor Island

Reef awash

Low land

Kempff Bay

Drake Head

Twin Peaks

Lazy Bay

Egg Island

Low Rolling Plain

Sandy Point

Rodman Reach

Tanner Head

Cape Alitak

Five fathom Ridge
Said to extend
from Cape Alitak to Cape Trinity

Cape Hepburn

Middle Reef

High bold cliffs

Conspicuous black Monolith

Cape Trinity

ALASKA PENINSULA

BAY

SUB-SKETCH OF
SNUG HARBOR.

Ast st

Cannery

0 1/2 1.
Scale of Miles.

ALITAK BAY
SNUG HARBOR
AND
LAZY BAY
KADIAK ISLAND
ALASKA.

From a Sextant Reconnaissance
by the Officers of the
U. S. Fish Com. Str. "ALBATROSS"
in August 1900
under the direction of
Comdr. Jeff'n F. Moser, U.S.N., Comdg.

Scale 1/40,000.

Soundings are expressed in fathoms, reduced to the mean of all low-waters observed.

Astronomical Station { Lat. 56° 59' 26" N.
Long. 158° 12' 22" W.

Variation 29° 16' E'ly, by Compass Declinometer

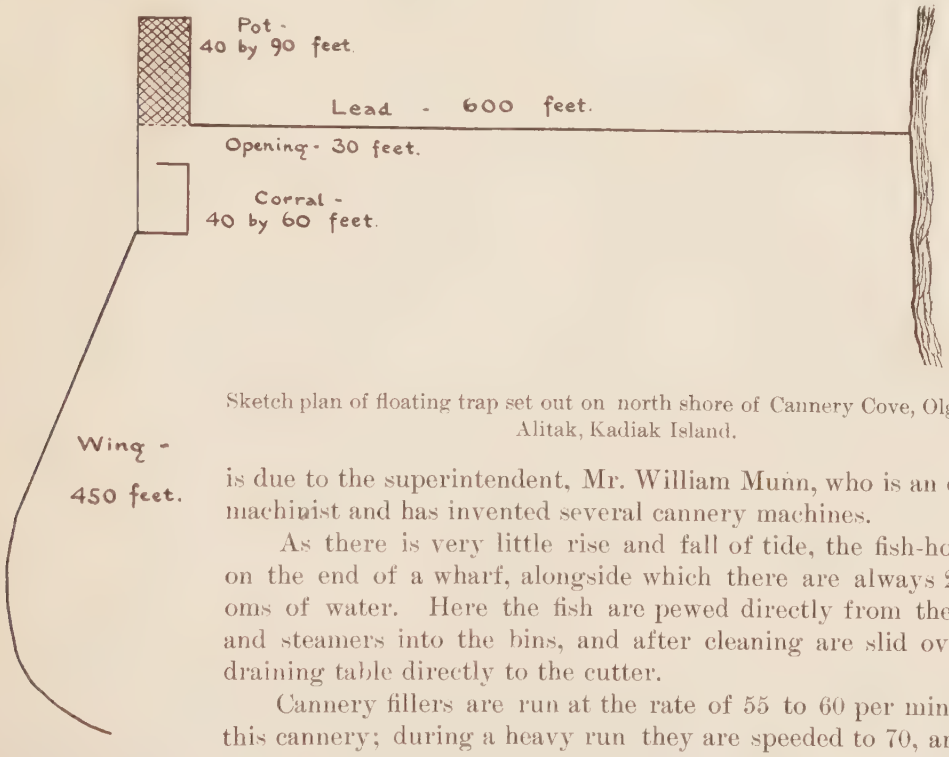
△ Triangulation Point.
◬ Astronomical Station.

Triangulation by Lieut. Hugh Rodman, U.S.N.
Astronomic and Magnetic Observations by Ens. A.J. Hepburn, U.S.N.
Hydrography by Ensigns C.R. Miller and C.S. Kempff, U.S.N.

Approved:
Jeffn F. Moser.
Commander, U.S. Navy, Commanding.

and in 1893 it entered the Alaska Packers Association. It has been operated every year since its construction, and now has a running capacity of 1,000 cases per day.

This cannery, also known as the "Olga Bay" and the "South End," is well arranged and more than usually clean. The cannery machinery consists of 5 retorts, 1 filler, 1 topper, 1 solderer, and 1 cutter, with 1 filler and 1 topper in reserve. It has a complete can-making outfit, and it is claimed that 900 cases of cans have been made in one day, but 700 cases would be a better average. The plant has been successfully operated by running all the machinery together, salting the cans at once at the can-makers, and conveying them to the filler. In this way, when the machinery runs well, 700 cases can be turned out daily. The successful operation of this plant



Sketch plan of floating trap set out on north shore of Cannery Cove, Olga Bay, Alitak, Kadiak Island.

is due to the superintendent, Mr. William Munn, who is an expert machinist and has invented several cannery machines.

As there is very little rise and fall of tide, the fish-house is on the end of a wharf, alongside which there are always 2 fathoms of water. Here the fish are pewed directly from the boats and steamers into the bins, and after cleaning are slid over the draining table directly to the cutter.

Cannery fillers are run at the rate of 55 to 60 per minute at this cannery; during a heavy run they are speeded to 70, and 500 cases have been run through at 80 per minute. This high rate requires a thorough knowledge of the machinery and delicate adjustment, and it is doubted if the cans at a much higher rate than 60 can be successfully handled at the filling table for any great length of time.

The tin plate used was 100-pound for bodies and 95-pound for tops, all imported. One pound of solder was used per case for hand-made cans and three-fourths of a pound for the machine-made. In salting the cans one-sixth ounce of fine granulated salt was used per can, or one-half pound per case.

Occasionally, when the run is large, a little incidental salting is done.

The Chinese contract was the same as at Chignik. The fishermen received $50 each for working the ship to and from the cannery, discharging and loading, and 8 mills per case for each man, with full board, except the Italians, who messed themselves and received 35 cents each per day for rations.

Transportation is by company's vessels, which are moored in Chips Cove.

At the time of our visit the superintendent was experimenting with a machine of his own invention for cleaning fish, which, it is learned, has since proven successful, and a large number have been ordered for the 1901 season. If this machine is placed in successful operation, it will not only save much labor but will afford a great relief in the fish-house, which is usually much crowded and overworked during a heavy run.

In 1900 the Arctic cannery employed 40 white fishermen, 9 white cannery-hands, 10 natives, and 59 Chinese. It used six seines, having a total length of 1,200 fathoms, each from 100 to 350 fathoms long, 100 to 130 meshes deep, 3-inch mesh, all hung straight, valued at $1.50 per fathom. It had also 3 bales of spare web, and material on hand to make a 400-fathom purse seine if required.

A floating trap had also been constructed by the Italian fishermen. It was first used in 1899, when it took about one-half the pack, while in 1900 it only took about 50,000 fish. This trap was located about one-half mile from the cannery and a short distance east from the mouth of the home stream. It had a shore lead of 100 fathoms, a corral 40 feet by 60 feet, pot 40 feet by 90 feet, curved wing 75 fathoms, and a 30-foot opening. There were used in its construction 300 keg floats, several thousand cork seine floats, 50 anchors from 200 to 400 pounds each, 3-inch cork line, 3½-inch anchor line, 1¾ to 2¼ inch pursing line. The web was 3-inch mesh, of from 15 to 45 threads, disposed according to strain. This trap was valued at $2,500.

The following boats were used: Two fish lighters, $250 each; 1 cargo lighter, $500; 6 seine boats, $60 each; 2 fish scows, $100 each; 1 otter boat, $100; 18 dories, $30 each; 3 skiffs, $15 each; 1 hand pile-driver, $100.

The following vessels (owned by the cannery) were employed:

Class and name.	Tons.	Crew.	Value.
Steamer Hattie Gage	42	5	$17,000
Launch Aurora	5	2	2,500
Bark Electra	939	(1)	15,000

[1] Fishermen.

The salmon pack in 1900 consisted of 32,342 cases of redfish, 13.5 to the case, packed June 8 to August 13. No other fish were packed and none salted.

Kodiak Packing Company.—In 1889 a company, organized under this title, sent a cannery outfit to this district on the bark *Lizzie Williams*, which was wrecked in April on Tugidak Island and became a total loss. The superintendent returned at once to San Francisco, obtained another outfit, and erected a cannery at the head of Snug Harbor. It was operated in 1889 and 1890, and in 1891 its quota of fish, under previous arrangement, was packed in the cannery of the Arctic company. It entered the pool formed by the Alaska Packing Association in 1892, and in 1893 became a member of the Alaska Packers Association. Most of the machinery has been removed, but the buildings are substantial, in excellent repair, and the cannery could be placed in operating condition in a short time by installing machinery. It may be said to be in reserve. It is locally known as the "Snug Harbor" or "Oliver Smith" cannery, and, when operated, it obtained fish from the same streams as those now fished by the Arctic Company.

OLGA BAY STREAMS.

The streams fished by the Arctic Packing Company are all situated on Olga Bay, except one on the outside coast, which, however, is only resorted to at rare intervals. There are three streams which run redfish: The North Olga, or home stream, where the cannery is now located; the South Olga stream, the original site of the cannery; and Silver Salmon Bay stream, in the extreme western end of the bay. The latter runs very few redfish and can not be depended upon, but, with another smaller stream that empties into a cove west of the northern end of the Narrows, it has a small run of cohoes. This species may be found in other streams, but they run after the cannery closes. Humpbacks and dog salmon are found in all the streams, but, as the cannery only seeks redfish, little is known of the abundance of other

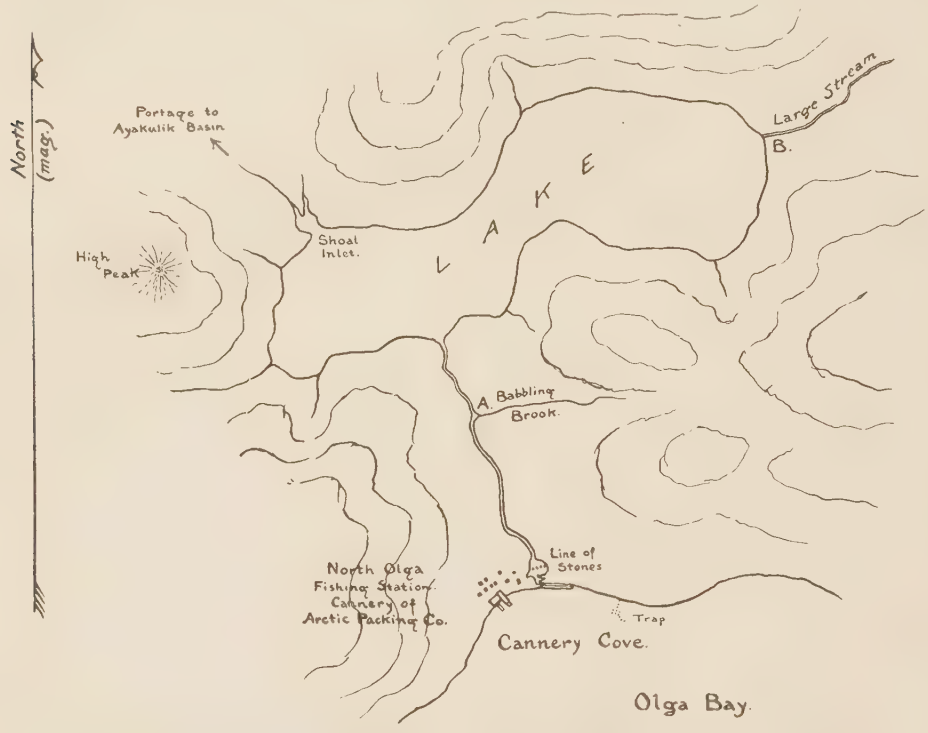
Free-hand sketch of Olga Bay and vicinity, Alitak, Kadiak Island, showing locations of lakes and streams and the species of salmon found.

species. The Horse Marine stream formerly carried a few redfish, but its entrance has become grassy and they have ceased entering. The redfish school around the shores of the bay, usually near the streams; they may appear in one place in large numbers and a few hours later be miles away. Their movements here seem to depend upon the state of the weather and the direction of the wind and sea.

The Olga Bay streams were examined by Mr. Fassett, and from his notes the following account is condensed.

North Olga, or Home Stream, empties into the bay just east of the cannery. It is about 1½ miles in length and flows in a general south-southeasterly direction from the lake which is its source. The stream bed winds through low rolling hills

covered with a rank growth of coarse grass and shrubs. In places it broadens out into small grassy flats with low banks of earth and stones; again, the banks are high, steep, and grassy, with rocky ledges outcropping in places. The bed is chiefly of shingle and gravel, with some sand in the wider parts; at the rapids and riffles there are bare rocky ledges, small bowlders, and heavy stones. There are no falls in the stream, but several short rapids, none of which, however, would prevent even a humpback salmon from easily ascending. The fall from the lake to high-water mark of the bay is about 40 feet. At the lake the outlet is about 18 feet wide with an average depth of 1½ feet, and the current sluggish, less than 1 knot per hour.



Free-hand sketch of North Olga stream and lake, Olga Bay, Alitak, Kadiak Island.

About half a mile from the lake the stream receives a small tributary known locally as Babbling Brook, which drains the rolling hills to the eastward. There are also several tiny rills carrying seepage from the surrounding hills into the stream, but their total volume is inconsiderable. At the beach the discharge of the stream is about 12 feet wide, average depth 2 feet, and current about 1½ knots per hour. A short distance from the beach of Olga Bay the stream widens into a small lagoon-like basin, into which the tide water backs through a narrow channel. Apparently this channel shifts from time to time with the changing of the shingle after heavy southerly gales; at present the outlet bends sharply to the eastward and runs parallel to the beach, separated from it by a ridge of shingle a few feet wide, and 100 yards distant discharges into the bay. The lagoon, so called, is about 160 yards long and

half as wide; the land about it is low and fairly flat, and covered with a dense growth of raspberry bushes, shrubs, and coarse grass. Tide water backs into the lagoon.

The water of the stream is slightly discolored by the vegetation, and does not seem to be very pure. But few dead salmon were noticed on the banks, or about the lake outlet; nor were more than half a dozen redfish seen to pass into the lake during a period of over an hour. Young salmon, from 1½ to 3 and 4 inches in length, were seen in numbers, however, in the upper part of the stream close to the lake, and a few were noticed in the lower part of the stream in the straight runs, hugging close to the undercut banks. Many flounders and sculpins were seen in the lagoon, and they, with the Dolly Vardens and cut-throats, were gorging themselves with the eggs of the humpbacks, which latter were spawning at the time.

Above the lagoon, in every broad pool or pond-like widening, mallard ducks with young were found feeding, but upon what could not be learned. The lake could not be examined for lack of time and facilities. The sketch of the lake was made from the vicinity of the outlet, and can be regarded merely as a crude approximation.

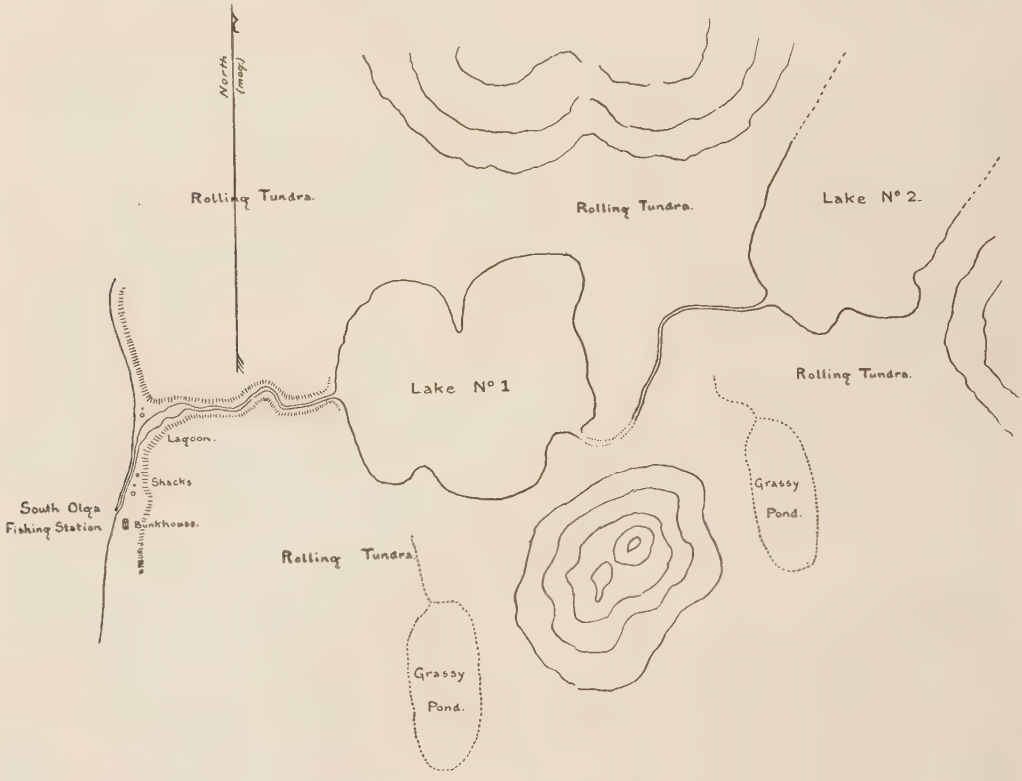
The lake is said to be about 3 miles long, east-northeast and west-southwest, and is about 1¼ miles across from the outlet to the Ayakulik Portage. It appears, and is reported to be, deep, with generally bold shores, dropping quickly into deep water. The beaches near the outlet are very narrow, of water-worn bowlders and rubble, with here and there small patches of sand and shingle. On the north the hills rise quickly to a considerable height, and the same is true of the west end; an intermediate point to the northeast of the outlet, which juts into and divides the lake into two main bodies, rises to the southward in an even gentle slope, also to a good height. Northwest of the outlet is a low valley making back from a small inlet, and through it a small portage leads to the waters of a lake draining into the Ayakulik River. The shores are everywhere covered with the same rank, dense growth of shrubs and grasses, and on the hillsides are extensive patches of scrub alders and cottonwoods.

Seepage enters the lake from every little ravine in the hills, and there are reported to be feeders, as indicated on the sketch, none of which, however, were examined. The large stream that enters the head of the eastern arm through a broad valley was carefully examined some months ago for a hatchery site, and it is reported that the conditions here are all that could be desired; there are broad spawning-grounds, excellent natural facilities for taking ripe fish and for holding them if necessary, ample level area for extensive nursery ponds and for building purposes, and a splendid supply of excellent water by gravity; the chief objections would be the cost of transporting material and supplies, and the isolation.

The Babbling Brook was also examined and found suitable for hatchery purposes. Where the brook joins the main stream there is a broad widening forming a good-sized pond in which retaining and ripening corrals could readily be fenced off, and where fry could be looked after in the spring until large and strong enough to be set free. The low ground in this little pocket in the hills is ample for building purposes, and the buildings would be well protected from the free sweep of the winter gales. The water from Babbling Brook is very clear and pure, would require but little filtering, and is said never to freeze. There is the added advantage of its accessibility, twenty minutes by trail taking one to the cannery. The waters of the

brook would furnish an ample supply for a plant of large capacity; any other water required could be obtained from the stream or from the lake by gravity; the bed of the brook at this point is about 18 feet below the normal level of the lake.

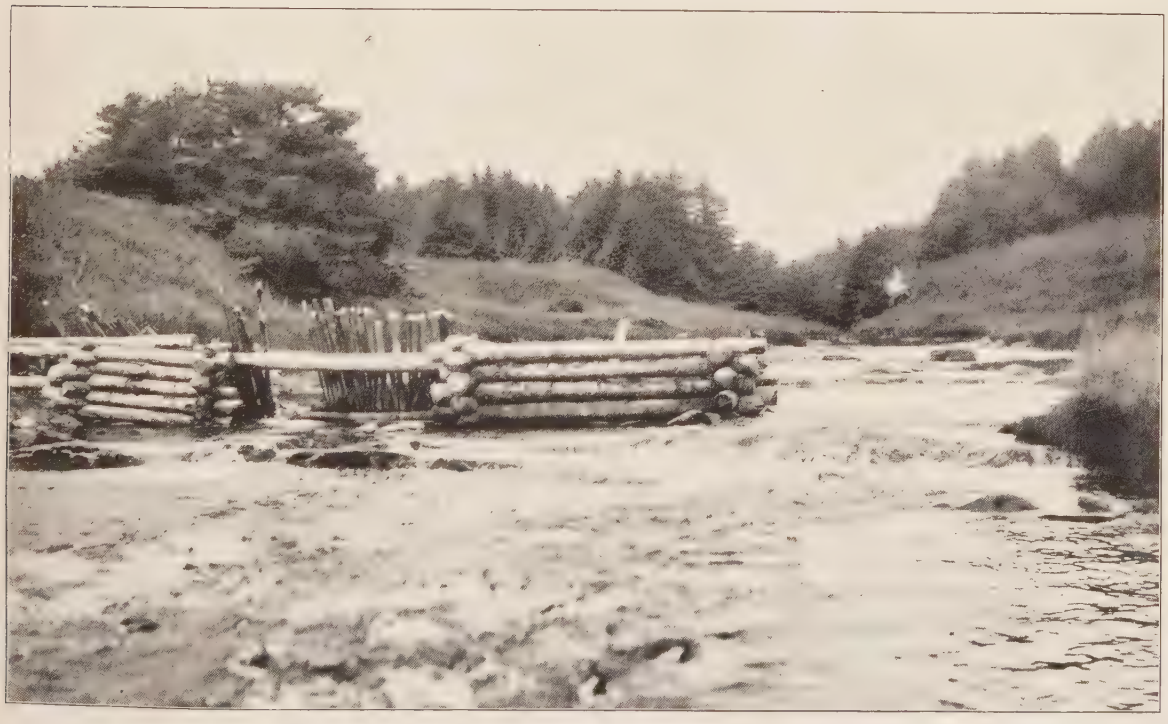
South Olga Stream is the outlet of the lower of a chain of lakes lying in a broad low valley eastward of the southern end of Olga Bay. It flows for about three-fourths of a mile in a general west by south direction, winding through a ravine in the tundra-covered mesa to the bay shore, then turns sharply to the southward parallel to the beach, back of a bare narrow shingle barrier, and a quarter of a mile distant enters the bay. The outlet at the lake is about 30 feet wide, 12 to 14 inches



Free-hand sketch of South Olga stream and lakes, Olga Bay, Alitak, Kadiak Island.

deep, with a current of less than a knot an hour. The bed of the stream is broad, full of small bowlders and rocky outcrops in its upper third, generally of gravel and shingle, and quite gradual in descent; the fall between lake and exit being not more than 12 or 15 feet, salmon would not have the least difficulty in ascending, as the few rapids in the upper course are low and insignificant. About 400 yards before it reaches the beach the stream broadens out into a lagoon-like pond 100 yards wide, with a sluggish current and marshy banks. This is a favorite breeding-place for mallard and teal ducks. At one time, apparently, the exit was at the western end of the lagoon, but the shingle bank, thrown up by some heavy westerly gale, has

HEAD OF NORTH OLGA STREAM, ALITAK, KADIAK ISLAND.



ZAPOR IN STREAM ENTERING LITNIK BAY, AFOGNAK ISLAND

driven it to the southward as described; the present fishing station is located on the beach at the exit. Considerable of the volume of the stream must seep out through the shingle, for at its visible exit it has shrunk to barely 10 feet in width, 10 or 12 inches in depth, with a velocity of 1½ knots an hour. In the lagoon the bottom is of sand and shingle. The banks of the stream, except the lagoon, are steep inclines covered with a dense growth of rank grasses and moss. Tide water rarely backs up into the lagoon; during heavy westerly storms the seas break over the shingle barrier. The water is rather discolored, this being particularly noticeable below the lagoon.

Red salmon were running in numbers up the stream at the time of our visit, though very few were observed entering the lake during the short time spent at the outlet. Large schools were seen in the lagoon, and it is possible that the fish school there before finally ascending to the lake. No dog salmon or humpbacks were noticed, though both species are said to run at times. The course of the stream was followed from the lake outlet to the exit, except a short distance above the lagoon, and it is not believed there were any barricades at that time; no signs or indications of them were discovered, and no well-worn trails were seen anywhere beyond the lagoon. It is not believed, therefore, that salmon have this season been taken in any other than the salt water of the bay. The entrance of fish could be stopped in a moment by merely laying a small piece of web across the beach at the stream exit, and probably this has been done when fish were scarce. Immense numbers were jumping about the bay in all directions on the afternoon of August 2, but no fishing was going on, as the crew stationed there had already taken their daily quota.

For want of proper facilities the lake could only be examined from a point near the outlet. Its axis is about east by north and west by south (magnetic), a mile in greatest length, by three-fourths of a mile average width. The shores are grassy on all sides, and the beaches of gravel, sand, and shingle, with rocky ledges and outcrops in places, shelve gently into deeper water. The lake did not have the appearance of more than moderate depth. The other lakes shown on the sketch were not seen by the party at this time, but had been previously sketched from the mountains northwest of Snug Harbor. Very few dead salmon were seen along the banks of the stream, and none on the beaches of the lakes. No entering streams or feeders were to be seen.

It did not appear that the locality is well suited for hatchery purposes; the lake water is far from pure and would require careful filtering, and a supply, as far as could be seen, is only to be had by pumping.

Horse Marine Lagoon, at the eastern end of the eastern arm of Olga Bay, is separated from the latter by a narrow grass-covered shingle spit. The spit extends north from the southern shore of the bay, leaving a narrow opening, the exit of the lagoon, between its northern end and the opposite shore. The lagoon is about five-eighths mile in length, east-northeast and west-southwest (magnetic), in the general direction of the short valley into which it makes; the width is about one-third its length. It is shallow, with bottom of sand, gravel, shells, and shingle, and is badly choked by a thick matted growth of coarse eelgrass; the shores are indented with several small sloughs and coves. The banks were everywhere covered (August 2) with a dense growth of coarse grasses and rank weeds, wild flowers, and berry shrubs. The small tides of the outer bay are felt to the head of the lagoon, but to no great extent; very

little of the lagoon bares at ordinary low water. The water is brackish and slightly warmer than the bay; no temperature observations, however, were made. Many humpbacks and a few dog salmon were seen schooling just inside the entrance, while Dolly Varden trout of large size, starry flounders, and sculpins were seen in great numbers. A few humpbacks were spawning in the lower part of the lagoon and in the slough on the northern side.

A mile from the northeastern end of the lagoon, at the head of the valley, is a deep fresh-water lake. This is an irregular basin about 1½ miles in greatest length by less than half a mile average width, the major axis lying northwest by north and southeast by east (magnetic). It is surrounded by hills on all sides except at the valley through which it drains. It was not practicable to examine the lake at this

Free-hand sketch of Horse Marine lagoon, stream, and lake, Olga Bay.

time. No entering streams were to be seen from the outlet, though three or four valleys in the distance probably carry small feeders, where there are doubtless good spawning-beds. It is not doubted that there is a suitable location for a hatchery somewhere on this lake, as the indications point to a good supply of water by gravity from the surrounding hills. The lake is drained by a shallow stream which follows a winding course for 1¼ miles through the valley and enters the head of the lagoon. The floor of the valley is undulating, covered with grasses, moss, wild flowers, and scrub in its greater part, with some fair-sized alders, willows, and spruce trees on the northern side. The stream flows with a velocity of about 1½ to 2 knots an hour above the rapids near the lagoon, where it is about 30 feet wide by 8 inches average depth. Above the cascade, in the upper part, the stream is broad with fine gravel

bottom, sluggish current, and grasses growing in the water along the shores. Elsewhere the bed of the stream is rocky with some gravel and shingle in places. It is full of low riffles and a few short rapids, besides the cascade and rapids indicated on the sketch, and the total fall from lake to lagoon is about 45 feet.

There are no artificial obstructions in the stream, which was followed its entire length, and no natural ones to prevent the ascent of the more vigorous species of salmon or trout. Humpbacks would probably find difficulty in passing the cascade, and a number of them were seen in the pools below it. Many small fry, 2 to 4 inches in length, probably young salmon, were seen in the upper reaches of the stream above the cascade and in the lake in the vicinity of the outlet.

The Horse Marine stream is referred to in Dr. Bean's report on the salmon and salmon rivers of Alaska, page 183, as the North Fishing Station, and the same name is used by Captain Larsen on his sketch map. The report gives a brief description of the location as seen on September 9. This stream was formerly good for several thousand redfish, but since the eelgrass grew up and filled the lagoon this species has abandoned it. About five or six years ago 1,500 redfish were taken from the Horse Marine, but during the last three years not a single redfish has been secured.

In Olga Bay the redfish run early. Fishing commences June 7 to 9, though they are not numerous during June; still the cannery expects to pack 5,000 cases by July 4, when the big run sets in and continues until the first week in August. They then begin to slacken and by the end of the month are not numerous enough to fish for. During this season (1900) the run was heavy and a much larger pack could have been made had there been more material on hand. In 1896 the run of redfish was small, but there were a large number of grilse, and it is said they were all males with the generative organs fully developed. One hundred and ninety-five cases of these were packed; the flesh was very red, firm, of fine flavor, but more juicy than full-grown salmon, and their weight averaged about 1 pound each. It is estimated that the following redfish were taken from Olga Bay during the last three years: In 1898, 430,000; in 1899, 400,000, and in 1900, 420,000. The Arctic cannery utilized all these fish except in 1898, when the two canneries at Uyak fished here, and together took about 50,000, and Karluk received about 10,000; and in 1899 the Uyak canneries received about 15,000. No stream tallies are kept, but the average value of 400,000 redfish for the section is probably a fair estimate, of which 100,000 are taken in the vicinity of North Olga stream, 200,000 in the vicinity of the South Olga stream, and 100,000 in Silver Salmon Bay and scattering.

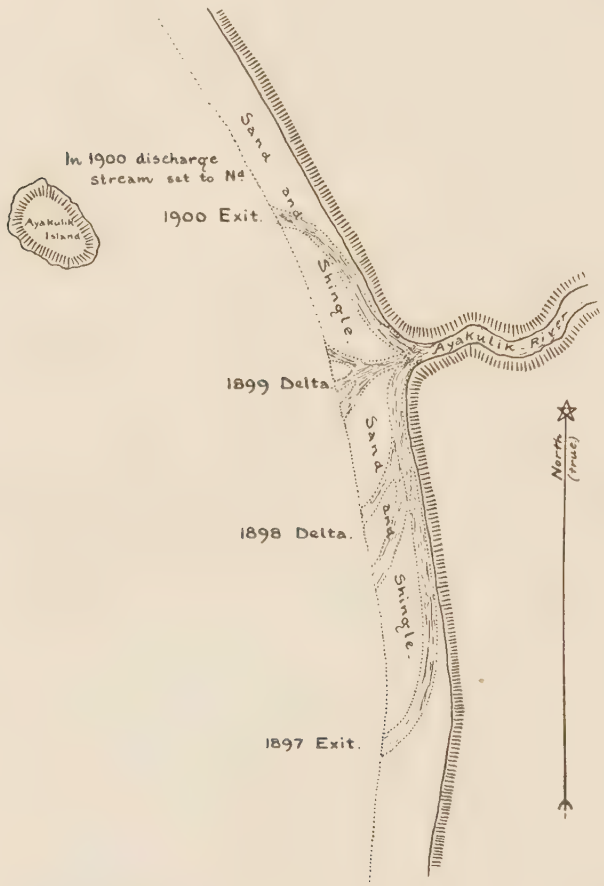
The cannery also receives a few fish from other places. In 1898, 60,000 redfish were taken at Ayakulik, and 35,000 were received from Chignik. In 1900 they received 25,000 from Ayakulik taken by Karluk fishermen.

Cohoes do not seem to be abundant; they first appear July 15 to 20, and straggle in small numbers until after the cannery closes. They are not packed at this cannery unless the redfish run is very slack, and then only to make up the guaranty.

King salmon occur as occasional stragglers and are rare visitors. Humpbacks and dog salmon are waste species here, and are used only by the natives for ukala. The former are noticed early in July and run throughout the season; the latter are seen soon after the redfish appear, and straggle throughout the season. There is no run of steelheads; a few individuals are taken at times and used by the cannery

hands. Dolly Varden trout appear a few days before the redfish and remain throughout the season. Cut-throat and rainbow trout are seen in the streams, but none have been noticed in salt water. Cod and halibut are seen in small numbers around the fisheries, and in greater numbers around the canneries, where they are attracted by the offal. Flounders are plentiful; shad have never been seen here.

Ayakulik River is on the western side of Kadiak Island, and empties into the sea midway between Low Cape and the Seal Rocks, to the eastward of Ayakulik Islet. It is small, but discharges a large body of water. Among cannerymen it is known as Red River, but this name should not be confounded with the Red River which lies 6 miles to the northward according to Coast Survey chart No. 8500.



Sketch showing changes in exit of Ayakulik River, 1897 to 1900.

The locality has been fished by the canneries on Kadiak Island for many years, but it has not been a favorite place, as the seining must be done on the open coast and can only be carried on during very favorable conditions. The seines are hauled in the surf and the fish thrown out on the sandy beach, then transported in carriers to boats in the river and carried to the waiting steamers outside. These fish are covered with sand and difficult to thoroughly cleanse on that account.

The following information relating to the river was furnished by the superintendent of the Olga Bay cannery: In 1897 and for several years prior to that time the stream, after leaving the ravine in the bluffs, turned sharply to the southward and skirted the line of bluffs for 1¼ miles, behind a broad spit of sand and shingle, before entering the sea. In 1898 the channel broke across the spit about halfway between the 1897 exit and the river mouth proper. In 1899 it ran straight out over the shingle to sea. This year the stream bends sharply to the northward, flowing along the base of the bluffs, and discharges about one-half mile above the ravine behind Ayakulik Islet. The fresh-water discharge now passes to the northward toward Seal Cape, and the salmon have been schooling in great numbers this year between the island and the main shore. They come from the northward, and it is

believed that the increase in this year's numbers is due chiefly, if not entirely, to the fact that Karluk fish making the coast in the vicinity of Seal Cape feel the influence of this fresh water, and, following it up, soon find themselves off the mouth of the Ayakulik, schooling in the open water, as described. As the stream has worked to the northward the catch of redfish has been observed to increase.

The run of redfish at Ayakulik this season has been very large, and it is estimated that the total catch amounted to 700,000 fish from the beach around the mouth of the stream. In the early part of August the humpbacks came in myriads; it is said that a boat could hardly pull through the dense masses when they were schooling, and that fishing for redfish then ceased. The weather was very favorable for conducting the fisheries at Ayakulik this year; the sea was exceptionally smooth, an excellent condition for outside beach work.

KARLUK.

A full account of the canneries, streams, and fisheries is given in my former report, pages 144 to 157, to which reference is made, and only changes or omissions, together with the 1900 statistics, will be referred to in this article. The operating canneries at Karluk are the Karluk Packing Company, the Hume-Aleutian Packing Company, and the Alaska Improvement Company; those of the Hume Canning and Trading Company and the Kodiak Packing Company are held in reserve. These are all the property of the Alaska Packers Association, and, with the cannery of the association at Uganuk, they are operated under one superintendent, with headquarters at Karluk Spit; there is a foreman at each operating plant. Karluk is the depot of supplies for the district, and affairs are conducted in much the same manner as noted under Nushagak and elsewhere, where several canneries under one organization are located in close proximity, that is, the stores and equipments are common to all and the fish are supplied equally. As the run at Uganuk is short, usually ending by the middle of July, the force at that cannery is transferred to the Karluk canneries on the completion of the pack. In 1898 and 1899 the three canneries mentioned as the operating canneries at Karluk were used, but the run of fish was so slack during those years that in 1900 only the Karluk Packing Company and the Alaska Improvement Company were employed in packing.

The Hume-Aleutian cannery was not operated, and as it was desired to increase the capacity of the Bering Sea canneries, the three fillers and three toppers of the former were removed and installed in the latter district. They expect to install new machinery in the Hume-Aleutian cannery in 1901. The reserve canneries are in the same condition as mentioned in my last report, though that of the Kodiak Packing Company can hardly be said to be in reserve, as practically all the machinery has been removed and the buildings used as warehouses, workshops, etc.

There has been no increase in the capacity of the operating canneries. The cannery machinery in each consists of 7 retorts, 3 fillers, 2 toppers, 2 solderers, 1 cutter, and 2 sets of canmakers. Usually 2 fillers only are used, giving these canneries a daily capacity of 1,600 cases, though by using a third filler the capacity might be increased to 2,400 cases; but that could hardly be kept up for any length of time, unless an additional topper is used, which may be taken from the can-making department. A fair capacity for these canneries as now installed is 2,000 cases per day.

The speed of the fillers, running at an average rate and in such a manner that the handlers are not crowded beyond their capacity, is 52 to 58 per minute, though it is claimed the machines, when well adjusted, will run at a speed of 80 to 90. At this rate the pack can not be handled unless the filling tables are very differently arranged.

A good average for the can-makers is 50 per minute. All cans are made at the cannery, of 100-pound tin for bodies and 95-pound for tops, of which 50 per cent is imported; 1 pound of solder is used to the case.

Transportation is by the vessels of the company and chartered vessels, and they usually make several trips during a season. If idle for any length of time, they are moored at Larsen Cove, a branch of Uyak Bay.

The Chinese contract was 42½ cents per case for machine-filled and 47½ cents for hand-packed, with the usual conditions. Fishermen's contract was $25 per month from the time fishing commenced until it ceased and 18 cents per case, divided equally amongst all; $40 per month from the time the vessel arrived until fishing commenced and from the time fishing ceased until the day of departure; full board from the time of signing until paid off, except the Italian crew, who boarded themselves and received 35 cents per day commutation. There are two classes of fishermen; one consists of Scandinavians, who operate on the Spit, and the other of Italians, who operate the Tanglefoot Bay side.

The streams and vicinity, together with the species, times of the runs, and other matters relating to Karluk, were fully described in my former report. It need only be said that the pack made here is essentially of redfish, all other species being incidental. Occasionally, after long intervals, there is an enormous run of humpbacks. There was such a run in 1890, and this season they were again very plentiful around the whole island. During our visit the seines were choked with them, and, as previously mentioned, at Ayakulik fishing for redfish ceased on account of the great number of humpbacks present. There are usually a few scattering king salmon around Karluk beach, most abundant in June, when a pack of from 500 to 1,000 cases is sometimes made. A few cohoes and dog salmon also occur, but the small pack usually made of the former comes from Sturgeon River. Steelheads are taken, commencing early in August and increasing during the latter part of the month, but never in sufficient numbers to utilize; thirty or forty may be taken one day and the next few days only three or four, or possibly none. Cod are abundant. Halibut are not plentiful, and neither shad nor sturgeon have been seen. Usually there are many trout, but this year they were very scarce.

The Karluk canneries this year fished the Spit and adjacent waters, Ayakulik, Uganuk, Little River, Eagle Harbor, and Kiliuda Bay, though the yield from the last two places was not over 9,000 fish. There seemed to be no contention this year over the fishing rights in this vicinity.

The fisheries at Karluk during the seasons of 1898 and 1899 were considered a failure, as only about 65 per cent of the general average of the past ten years was made. The canneries at Karluk, Uganuk, and Uyak combined have, for the ten years ending with 1897, made an average pack of over 200,000 cases per year, and at no time during this period has the pack fallen as low as for the years of 1898 and 1899. Some cannerymen claim that these slack runs are only temporary; others believe that they indicate the first sign of decline, and that while some years there

may again be large runs, the average will become less. In 1900, however, there was a large increase, the canneries under consideration packing about 220,000 cases. It will be interesting to note the future pack of this locality, as the hard fishing commenced in 1888, and the first output of the hatchery was made in 1896.

For future comparison it may be interesting to record the redfish statistics of the Karluk canneries for 1900, which are as follows:

Packed at the two Karluk canneries		2,031,971
Received from Ayakulik River	242,500	
Received from Little River	5,800	
Received from Eagle Harbor	1,000	
Received from Uganuk	24,000	
		273,300
		1,758,671
Sent to Uganuk from Karluk		9,000
Total redfish taken at or near Karluk Spit		1,767,671
Packed at the Uganuk Cannery		170,960
Received from Ayakulik River	17,500	
Received from Little River	17,300	
Received from Kiliuda Bay	4,900	
Received from Eagle Harbor	3,000	
Received from Karluk	9,000	
		51,700
		119,260
Sent to Karluk		24,000
Redfish taken at Uganuk		143,260

The following are the statistics for 1900 of the Karluk and Uganuk canneries combined. There were employed 171 white fishermen, 13 native fishermen, 43 white cannery-hands, 8 natives, and 263 Chinese.

There were used 10 seines, each 400 fathoms long and 185 meshes deep; 6 seines, each 250 to 300 fathoms long, and 120 to 160 meshes deep; and 3 hatchery seines, each 100 fathoms long and 80 meshes deep, all 3-inch mesh and valued at $1.50 per fathom. This, however, only represents a fraction of the material on hand. There is a warehouse filled with old seines, many bales of all kinds of webbing, and an abundance of floats, sinkers, cordage, etc. At Uganuk the two floating traps mentioned in my former report were used. These traps are valued at $1,500 each.

The following boats were used: Nine lighters, $500 each; 3 launch tenders, $90 each; 17 fish scows, $150 each; 20 seine boats, $150 each; 33 dories, $25 each; 1 hatchery scow, $150; 6 hatchery transporting cars, $30 each.

The following vessels were used:

Class and name.	Tons.	Crew.	Value.	Ownership.
Steamer Kadiak	58	9	$20,000	Owned.
Steamer Gertie Story	36	7	12,000	Do.
Launch Karluk	8	2	10,000	Do.
Launch Uganuk	8	2	10,000	Do.
Launch Delphine	5	2	2,500	Do.
Launch Ida	5	2	2,700	Do.
Ship Santa Clara	1,453	18	40,000	Do.

The ship *Indiana* and the bark *Merom*, which are accredited to the Alaska Packers Association cannery at Naknek, were also employed in part at Karluk. The bark *Merom* broke from her moorings off Karluk Spit on October 6, 1900, during a gale, and was totally wrecked on the rocks, losing 12,572 cases of salmon.

The following was the output in 1900:

Species.	Cases.	Number to the case	Dates.	Remarks.
Karluk Packing Co.:				
King salmon	475	4.9	June 9–June 28...	None salted.
Redfish	77,558	13.6	June 9–Sept. 14...	
Cohoes	1,382	7.2	Aug. 25–Sept. 14...	
Alaska Improvement Co.:				
King salmon	612	4.9	June 5–June 28...	Do.
Redfish	69,712	13.9	June 4–Sept. 21...	
Cohoes	2,791	8.0	Aug. 25–Sept. 21...	
Uganuk:				
Redfish	13,370	12.8	June 9–July 17...	

The hatchery operated by the Alaska Packers Association on Karluk Lagoon was visited by Mr. Fassett, whose report will be found on pp. 331–348.

UYAK.

The Uyak Bay canneries, of the Pacific Steam Whaling Company and Hume Bros. & Hume, were fully described in my previous report, pages 158–159, and will only be referred to in connection with the statistics. These canneries are practically the same as in 1897, and as there are no redfish streams in Uyak Bay all the fish are obtained at a distance. The principal places fished are Karluk, The Slide, Waterfalls, Ayakulik, Uganuk, Little River, Eagle Harbor, Kushuack, Kukak, and Kiliuda Bay. Formerly the Afognak streams at Litnik, Paramanof, and Malinof were also fished, and it is said fish are still obtained at these places.

The *Pacific Steam Whaling Company* cannery uses steam boxes in the canning process for first cooking, and for second cooking 2 iron retorts; it has 1 filler in use, and 1 spare one, 1 solderer, and 1 cutter. Topping is done by hand. All cans are made by hand at the cannery, using 100-pound imported tin-plate for bodies and tops.

Fish are pewed from boats or steamers to the fish-house on the end of the wharf, and when cleaned are transported by handcarts to the cutters. The cannery has a capacity of 900 cases per day.

The Chinese contract was the same as that of the Karluk canneries. The fishermen's contract was $25 per month from the day of landing to the day of departure, transportation and full board from the time of leaving the home port until the return to the port of departure, and $15 per thousand fish.

During the season of 1900 the cannery employed 64 white fishermen, 6 white cannery-hands, 4 natives, and 56 Chinese; they also purchased fish from 26 natives, who were paid from $30 to $35 per thousand.

They used 5 seines; one 700 fathoms, one 550 fathoms, and three 350 fathoms long; $2\frac{3}{4}$-inch to 3-inch mesh, and 180 meshes deep. They have 10 spare seines; average value of all, $1.50 per fathom.

There are 5 lighters, $450 each; 15 seine boats, $70 each; 3 sailboats, $90 each; 13 dories, $30 each; and one pile-driver, $1,000.

The following vessels (owned by the company) were employed: Steamer *Shelikoff*, 101 tons, crew 10, value $36,000; launch *Kenai*, 5 tons, crew 2, value $7,000. Transportation of spring outfit and fall pack is by calling vessels of company.

The following was the output in 1900: Redfish, 29,384 cases, 13.7 to the case, May 28 to August 25; humpbacks, 1,025 cases, 21 to the case, July 20 to August 25.

Hume Bros. & Hume.—This cannery operates 4 retorts, 1 filler, 1 solderer, and 1 cutter, and tops by hand. All cans are made by hand at Uyak of 100-pound imported tin for bodies and tops. The fish are handled in the manner noted under the preceding cannery. The Chinese contract was the same as at Karluk and the fishermen's contract the same as given under the Pacific Steam Whaling Company's cannery.

The following are the statistics for the Hume cannery, season of 1900: Employed 52 white fishermen, 9 natives, 12 white cannery-hands, 56 Chinese; used 10 seines, from 150 to 350 fathoms long, 160 meshes deep, 3-inch mesh, valued at $1.50 per fathom; 4 lighters, $400 each; 12 seine boats, $120 each; 1 whitehall boat, $75; 20 dories and skiffs, $20 each; 1 pile-driver, $1,000.

The following vessels (owned by the cannery) were employed:

Class and name.	Tons.	Crew.	Value.
Steamer Equator	42	7	$12,000
Steamer Francis Cutting	59	8	10,000
Launch Herbert Hume	5	2	3,500
Bark Harvester	716	12	12,000

The following was the output in 1900: Redfish, 27,636 cases, 13.5 to the case, June 5 to September 20; humpbacks, 2,064 cases, 21 to the case, July 5 to September 20. Scattering cohoes and dog salmon were packed with humpbacks under pink brands. Salted 25 barrels of redfish.

The only places in this vicinity that might offer a hatchery site are Little River and Uganuk.

AFOGNAK.

From Uyak the *Albatross* went to Afognak, where an examination was made of the Fish Commission interests in that locality. During the four days in which these investigations were being conducted a sextant reconnaissance was made of Afognak (Litnik) Bay and approaches. As the locality is exceedingly foul and had never previously been surveyed, the chart accompanying this report will no doubt be useful to the Commission and to the mariner, and the following notes, so far as they relate to Afognak Bay, are referred to it.

In leaving the anchorage off the canneries at Uyak, of which a survey was made by this vessel in 1897 and published in Coast Survey Bulletin No. 38, a course was laid out of Uyak Bay clearing the shores and headlands of Capes Kiliugmuit, Ugat, and Uganuk by about 1 mile and entering Karluk Strait in mid-channel. A course through the middle of Karluk Strait seems perfectly safe and clear, and on this course the head of the vessel is found to point for about the center of Whale Island, possibly a little to the southward.

The Raspberry Island side seems to be the boldest, though no outlying dangers were seen anywhere. A short distance to the eastward of Dry Island, which lies off the entrance to an indentation on the southern shore midway in the strait, the tides coming through Shelikoff Strait meet the tides from the eastward around Whale Island. Outside and between the two small islets off the southeastern end of Raspberry Island is a sunken rock known as Thomas Rock. A fair berth of these two islets is said to clear the rock.

At Whale Island Karluk Strait forms two passages. The one to the southward, described by this vessel in Coast Survey Bulletin No. 38, was called Whale Passage, and the one to the northward is Afognak Strait. The latter should not be attempted by a deep-draft vessel until a satisfactory survey has been made, as there are indications at one point that there may not be sufficient depth at extreme low water for vessels of moderate draft, nor by any vessel without local knowledge, as the currents are strong and the passage very foul. Time did not permit the reconnaissance made by this vessel to extend through Afognak Strait. Sufficient only was done to appreciate the strong current and foul conditions of the shore.

The northern shore of Afognak Strait is foul in patches for nearly one-third of the width. On the southern side, at a point about one-third the length of the island from the western end, a bank makes off from Whale Island a considerable distance, and a reef, uncovered at low water, lies off the bight near the eastern end of the island, but the latter is off the fairway. Off Afognak village the reef extends a full mile to the eastward and from one-fourth to one-half mile to the southward.

The largest island off the southeastern end of Raspberry Island is Dearborn Island, the point of which seems to project farther into the strait. Off the southern end of this island there is a bare rock, always above water, which is a leading mark to the western end of Afognak Strait. The *Albatross* passed this rock, leaving it to the northward, distant 250 yards, and then brought it astern, steering for the saddle in Hog Island, which from this point is seen about one-third the length of that island from the northern end. After running half the length of Whale Island and well clear of the bank previously referred to on the southern side of the channel, the course was changed to head for the southern end of Hog Island, which was kept until that island was about 1 mile distant, when the course was gradually changed to the northward, rounding the reef off Afognak village into the bay.

Afognak (Litnik) Bay.—Litnik is a corruption of the Russian word Elitnik, meaning a place where fish are dried and prepared for future use, and is the name given locally and used throughout the Kadiak district to the body of water known to us as Afognak Bay, and to the river and lake at its head. Locally, the name Afognak Bay is applied to a small, shallow, foul cove, about 1½ miles to the westward of the village, on the northern side of the strait. Afognak is retained, however, in this report, for the large bay, as the President's proclamation and the Fish Commission records refer to it by that name.

Afognak (Litnik) Bay is on the eastern side of the extreme southern point of the island of that name. The approach from the westward (Shelikof Strait) is through Karluk Strait and Afognak Strait or Whale Passage; from Kadiak (St. Paul), through Usinka Narrows; and from sea, to the eastward, through the broad open waters between Pillar Cape and Spruce Island. The bay proper may be said to include the waters inclosed by a line drawn from Afognak village and the outlying reefs to Hog Island, thence by Skipwith Reefs to Lamb Island and the main shore, and is, approximately, 5 miles long by 2 miles greatest and one-half mile least width. The shores are heavily wooded, with high mountains lying back, from which ridges and hills project toward the bay. The entrance is much obstructed by islets and reefs, and great care must be exercised in the approaches, but the bay proper, except for one reef, is apparently clear of danger, with excellent anchorage at the head.

AFOGNAK BAY
(LITHE)
AFOGNAK ISLAND
ALASKA

From a sextant reconnaissance by the officers of the
U S Fish Com'n Str, ALBATROSS
Commander [illegible] F Moser [illegible]

Soundings are expressed in fathoms
reduced to the mean of all low waters observed

Astronomical Station { Latitude 58°02'24" N.
Longitude 152°48'09" W.

Variation, by magnetometer observations, 24° 36' E.

Triangulation and Topography by Lieut Hugh Rodman, U S N
Astronomic and Magnetic Observations by Ensign A J Hepburn, U S N.
Hydrography by Ensigns C R Miller and C S Kempff, U S N.

Symbols.
△ Sextant triangulation point. ⓐ Astronomical Station

Approved:
Geoffrey L. Moser.
Commander, U S Navy, Commanding

Main Salmon Stream
&
USFC Reservation
Litnik Village
R Pk Co's Cannery (Reserve)
Ast sta.
Arnkit Id
Bare Pt
Pt. Lipsett
Danger Reef
Native Village
Grave yard Pt
Foul Ground
Half tide Rock
Hog Island
Dolphin Pt
Treeless Island
Fox Bay
Afognak Strait
Whale Island

Scale.
Cables. Nautical Mile

Afognak village is located at the extreme southwestern end of the bay, and consists of two parts; the most southerly is a settlement with a population of about 175 whites and half-breeds, and to the northward (separated from the other by a high grassy bluff named Graveyard Point) is a native village of less than 100 inhabitants. Very foul ground, marked by kelp in summer, extends one-half mile off the principal village, increasing to 1 mile off Graveyard Point, and reaching halfway across the passage to Hog Island, a small wooded island, slightly crescent-shaped, with the cusps to the southwest. It is about half a mile long, in a general east-and-west direction, about 250 yards in width, and, when seen from the westward, it has a dip or saddle in the northern third. From high-water mark the rocky shelf projects in reefs a distance of 200 yards on all sides, and on the western end of the reef extends toward the village for three-tenths of a mile. These reefs are all marked by kelp in summer.

Nearly a mile to the northeastward of Hog Island are Skipwith Reefs, a line of high rocks always out of water, which, with Lamb Island, a larger wooded island, form the eastern side of the bay. Between Hog Island and Skipwith Reefs is a wide, clear passage, which might be called the Eastern Passage, and is the one to be preferred by strangers on entering or leaving the bay.

Danger Reef is a large reef, bare at low water, with deep water close to and all around it, and lies NNE. ½ E., 1.2 miles from Graveyard Point. It is estimated that it covers at three-quarter tide, or earlier. It is a bad reef when covered, as it is not marked by kelp and is not easily seen.

On the northern side, outside of the point marking the contraction of the bay, are three small, low, wooded islets lying close to the shore. The western one is Dot Island, which, when seen clear of the adjoining land, has a conical appearance. West of this islet, on the opposite shore, is a fine cascade, falling to the beach, from which most excellent water may be obtained. At the head of the bay, in the northwestern arm leading to the reservation stream, are several small islands. The first one is Winter Island, beyond which vessels should not go; it is high, rocky, and heavily wooded with spruce. The channel to the northward of Winter Island is obstructed by rocky ledges, and to the southward, as a point higher up is reached, it grows shallow and grassy. The latter is the boat channel to the river mouth.

Several cannery steamers from Karluk winter in this arm. They anchor to the eastward of Winter Island, and then haul the sterns of the vessels close up to the rocks on the island (which are bold), where they are clear of the ice forced out of the river in the spring.

At the extreme northern end a narrow extension of the bay, about a mile long by 1½ cables in width and 2 fathoms deep, is known locally as Back Bay. It should afford good anchorage for a small vessel. At its head are two humpback streams.

On the western shore, at the point where the bay turns to form the northwestern arm, are the locations of the canneries of the Royal Packing Company and the Russian-American Packing Company.

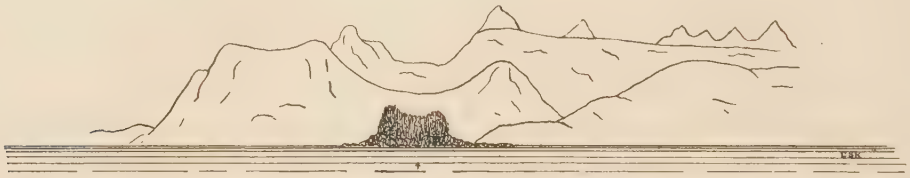
The history of these canneries is given in my former report, pages 163 and 164, to which reference is made. Nothing is left of the cannery of the Russian-American Packing Company. The buildings of the Royal, in which are stored a number of boats, and several detached houses are still standing and in fair condition. A watchman is kept here by the Alaska Packers Association during the summer, and during the winter the ship-keepers of the cannery steamers care for the property.

The anchorage in the upper bay off the cannery building is in 7 to 8 fathoms, mud bottom. It is said an anchorage may be made in summer off the native village south of Point Lipsett in 5 to 6 fathoms. This bight is, however, open to the eastward and can not be recommended.

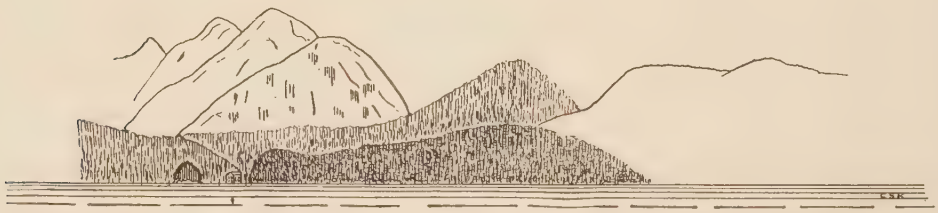
The following results by sextant and artificial horizon were obtained for geographical position at the high water, grass-covered rock on the western shore of the bay one-tenth mile south from the cannery building: Latitude, 58° 02′ 24″ north; longitude, 152° 48′ 09″ west; variation by compass declinometer 24° 36′ east.

Establishment from seven successive high waters, at moon's age from 17 to 20 days, XI^{h} 25^{m}. Mean rise and fall of tide during same period, 9.95 feet.

Sailing directions, Afognak Bay.—There are two passages used in entering this bay, one to the eastward and the other to the westward of Hog Island. In coming through Afognak Strait steer for Hog Island, and when three-fourths mile distant



Hog Island bearing SE. by E. ½ E., mag., in saddle of back range, clears Danger Reef.



Cannery building bearing WNW. ¼ W., mag., between Dot Island and adjoining shore to eastward, leads through East Passage and clears Danger Reef.

haul up for Lamb Island and run for it until the cannery building is open to the eastward of Dot Island; then change course for Dot Island, and when well clear of Danger Reef keep in mid-channel to the anchorage. At low water Village Reefs may be rounded by the kelp, and Danger Reef is then distinctly visible. The cannery steamers frequently pass between Village Reefs and Danger Reef, but local knowledge is necessary for this channel. The western passage should be used with caution, particularly at high water, as a stranger in keeping off Village Reefs may get on the foul ground on the Hog Island shore. For a stranger the eastern passage is recommended, as it is wide, straight, and apparently clear. In entering by this passage keep in mid-channel between Hog Island and the southern bare rock of Skipwith Reefs, and steer for Dot Island. On this course the cannery building will be seen between Dot Island and the adjoining shore to the eastward. When clear of Danger Reef follow the directions given under the eastern passage.

A line between Dot Island and Hog Island clears Danger Reef to the eastward one-fourth mile. On this line Hog Island will be seen filling a wide saddle in the distant mountains, and Dot Island will be slightly to the eastward of a V in the back range. The *Albatross* entered by the western passage and left by the eastern one.

AFOGNAK SALMON STREAMS.

At the head of Back Bay are two small streams, which at the time of our visit were literally choked with humpbacks. Cohoes are also said to run here, and several dead king salmon were seen. A small stream to the eastward of Bare Point carries a large number of humpbacks and is said to have a fair run of cohoes. Back of the village of Afognak is a shoal lagoon, or lily pond, which drains through a shifting channel and carries a few humpbacks and cohoes.

The reservation stream, previously referred to as emptying into the head of the northwestern arm of the bay, is the only redfish stream in this vicinity. A board of experts was appointed by the Commissioner in 1889 to examine the salmon streams of Alaska, and as this board spent the summer of that year in examining Karluk, Alitak, and Afognak, the results of which, so far as they relate to Afognak, are given on pages 185–188 and 207–208 of the U. S. Fish Commission Bulletin for 1889, the stream and lake will here be referred to in only a general way, though both were visited on several occasions by this party.

This year the redfish and humpbacks were very abundant in the reservation stream, and it is said that the stream can furnish, without injury, from 100,000 to 150,000 redfish a year, but of this there is no data, as all commercial fishing in late years has been done surreptitiously. The runs are remarkably early in this stream, scattering redfish appearing early in May and in large numbers by the middle of that month; by June 1 there is usually a lull. This is called the early run. The second run is said to commence with the spring tides in June, and the fish are then abundant until the middle of July, when the run grows slack, and by the last of the month it is practically over. If the water in the river is low the fish school around the mouth in great numbers, but upon the first rise they rush to the lake in a body. The redfish, upon arriving, school around the upper part of the bay, mostly along the western shore, where there are several excellent seining beaches.

Cohoes appear in small numbers the last week in July; the run is at its height the last of August, and continues, in diminishing numbers, until October. Humpbacks appear during the middle of July, and run in large numbers during August, growing less the latter part of that month and until the middle of September. The last fish are, however, of very poor quality. Dog salmon are not very numerous, and seem to run scatteringly with all other species. Straggling king salmon are seen at irregular intervals throughout the season. They are never abundant and are only recognized as occasional visitors. Steelheads are believed to winter in the lakes, and descend to the sea as soon as the stream opens in the spring. They appear at all times during the season, but are most numerous during the coho run. Dolly Varden trout appear with the earliest species and remain throughout the season.

The estuary and river to the falls, and the tributaries below, were crowded with humpbacks at the time of our visit. Great numbers were noticed trying to surmount

the falls, and many were seen thrown by their own velocity against the rocks in the rush to ascend. It is probable that few of this species gain the lake, and that most of them spawn in the lower course of the river and in the tributaries referred to. On my visit to the lake, for want of facilities the shores could not be examined except in the vicinity of the outlet and for about half a mile along the eastern side. Dead fish were not very abundant along the lake shores. All the dead redfish seen were opened, and it was found that 50 per cent of the females had not spawned and 30 per cent of the males had milt. A similar condition was previously noticed and referred to in my former report, pages 12 and 13. There may be some abnormal impediment in the genital pore, but it is more probable that in ascending a difficult stream the exertion is so great that the fish dies of exhaustion before it is fully ripe.

On August 15 the temperature of the surface water of the lake near the shore was 62° F., at 4 feet depth 58° F. and 59° F. The stream at the falls was 65° F.

It is said that the reservation stream has been fished by all the canneries each year until 1899, when only two corporations out of the three operating in the vicinity fished here. The natives report that this year (1900) one cannery obtained fish both from Malinof and from the Afognak stream; that a small schooner in charge of a member of the Brotherhood of Afognak Pioneers fished in the vicinity of the Royal cannery, entering and leaving the bay under cover of darkness. Several members of the organization, when questioned in regard to it, claimed to have no knowledge of such fishing. It is believed, however, that the natives' report is true.

The natives fish the stream, using, so it is said, the usual hook and pole, though at the summer village (Litnik), on the left bank of the stream near the mouth, several nets were seen which were also probably used.

ZAPORS.

From the earliest Russian times the natives were taught to barricade the streams by zapors, or barricades which were maintained for generations in the principal rivers. Upon the advent of the canneryman this method of holding the fish was encouraged and aided in every possible way. These zapors, as originally constructed, consisted of large cribs of heavy logs weighted with stone, placed at intervals across the river to form piers, at a suitable location. Between the piers other logs were secured, forming a line of support for the rails, or saplings, which were placed side by side, in the direction of the stream, with the butts upstream, embedded in the gravel or river bottom, and the other end resting on the timber support. The arrangement of these rails was the same as those used in the construction of the barricades in southeastern Alaska, and described in my former report, page 37. This arrangement permitted the water to pass through the interstices or over the ends, and prevented any fish from ascending. At a point below this dam a similar one was constructed, but near the center, or wherever the depth was most suitable, an opening was left for a sluice, the latter arranged to permit the fish to pass in, but not out. The fish were then impounded between the two barricades and easily captured.

The zapors of late date, however, consist of only one barricade, which prevents the fish from ascending. The one until lately maintained in the reservation stream was of this construction and was located a short distance above tide water, below the first falls, about a mile from the low-water mouth of the river proper. Three cribs

Bull. U. S. F. C. 1901. (To face page 244.)

CASCADES IN LITNIK STREAM

Many humpbacks in pool. Salmon struggling in falls.

formed the piers, and at the time of our visit the northern crib had been removed and was lying on the rocks a short distance below. This zapor, or rather a zapor, has been maintained at this point for many years. It was carried away during the winter of 1895 and 1896 and rebuilt by the natives as soon as the conditions permitted. In August, 1899, the master of one of the Alaska Packers Association cannery steamers, with the assistance of some natives, pulled out the northern crib. As this made but a small opening which could readily be closed, a party from the *Albatross* dismembered the remaining cribs, piled the timber and rails on shore, and burnt them. The stream is now (August, 1900) clear of artificial obstruction.

INHABITANTS.

The inhabitants of Afognak consist of Kadiak Eskimos, Russian half-breeds, and a few white hunters and fishermen. As much complaint has been made in this locality, not only on account of the illegal fishing of the reservation stream by the canneries, but by the inhabitants in relation to their condition and surroundings (see salmon inspector's report, 1899, pp. 38–48), it is deemed necessary, in order that the Commission may be advised of the facts, to state the situation as it appears to me after our visit.

When Alaska was under the management of the Russian-American Company the time arrived when they had in their employ many men who had grown old in their service or who had lost their health and could not very well be discharged and thrown upon their own resources. Upon representing this condition to the Russian Government an order was issued, in 1835, directing the company to locate, as permanent settlers, such of the employees as had married native or half-breed women, and who, on account of age or ill health, could no longer serve the company. The latter, under this order, was obliged to select suitable land, build comfortable dwellings, furnish agricultural implements, seed, cattle and fowls, and a year's provisions. The settlers were exempt from taxation and military duty, and the Russians were known as colonial citizens and the half-breeds as colonial settlers. The eastern side of Cook Inlet, Afognak Island, and Spruce Island were selected as most suitable for settlement, and the half-breeds now forming the larger part of the population at Afognak village are largely descendants from these colonial citizens and settlers. The early name of the village was Ratkovsky. The half-breeds have always lived on a higher plane of civilization than the natives and are more industrious. Among them are a number of skilled craftsmen, such as carpenters and boat-builders, and in the latter occupation it is said they excel the whites usually employed at the canneries.

In our investigations in Alaska we have come in contact with all the different phases of native life, from the Haida of the south to the Innuit of the north, from the Athapascan of the east to the Aleut of the west, and there are few places that can equal Afognak in natural resources for native life. None need suffer here, and if any do it is through their own neglect. Potatoes and the hardier vegetables of all kinds grow well and can be stored for winter use; hay can be made for cattle; the waters teem with fish, not only with salmon during the summer, which may be cured for winter use in practically unlimited quantities, but all during the year cod may be taken in numbers on the adjacent banks. The furs are not all gone yet; bear, fox, and mink are still found in limited numbers, and the catch of sea otter

this year has been comparatively large. As for the means for purchasing other provisions and clothing, it is here in the hands of any industrious man or woman. There is a great demand for dried fish—ukala—in all the mining regions of the north, principally for dog food. The stores, of which there are two in Afognak, representing large trading companies, pay in trade (provisions and clothing) 2 cents per pound for ukala, and will purchase all brought to them. For the use of the natives here the supply of salmon has not decreased, and there should not be the slightest difficulty in easily obtaining in a short time all that is required for the family during the winter, and afterwards ukala can be made for sale or trade. We were not at Afognak during the redfish run, but it is said that it was very large; the humpbacks were running at the time of our visit, and they were very numerous. It was not necessary to hook them out of the stream; when wanted for examination we simply kicked them out on the bank. To show the abundance of fish, it may be mentioned that the ship's dog dragged many struggling ones out of the water.

The women, assisted by the old men and children, usually prepare the ukala and do the garden work, so there is no excuse for the able men not seeking employment in other fields; but the latter fancy that they must hunt, and imagine that they can do nothing else, or rather, that it is degrading to work. In former times hunting formed the chief element of support, and while the fur-bearing animals have not entirely passed away, their numbers have declined to such an extent that the income derived from this source can now only be reckoned as incidental. The sea-otter hunter was an important man in his village; extensive preparations were made before his departure and he was feasted upon his return. He was looked up to as a leading spirit in the locality. The sea otter is practically passing away, but the hunter remains, and reports are made that he is starving. Possibly he may be short of food at times, but it is because he is not willing to exert himself; he is a sea-otter hunter in a sea that has few left, and he claims he can do nothing else.

There is another field in which the native can earn sufficient money to provide for himself and family not only the necessities of life, but many of the comforts and a few luxuries. It is in cannery work. Frequent inquiry has been made at the canneries, and the reply has always been to the effect that they are more than desirous to employ all the male population in the surrounding district, if they are steady and reliable, and to give such labor employment throughout the season. Quite a number of the inhabitants of Afognak are so employed, several holding positions where skill is required, but the majority are shiftless, stop work after having earned a few dollars, and expend it in spirits if they can get it. The canneries, however, do not want a class who can not be depended upon in time of need.

Unskilled labor at the canneries commands from $1 to $1.25 per day with good board, and, as the season in this district is long, a reliable hand may earn from $125 to $150 during the summer—more than sufficient to carry him through the winter very comfortably if he is at all thrifty. The canneries will also purchase fish from the natives, paying from $30 to $35 per thousand for redfish. The hatchery at Karluk is partly supplied with fish taken by natives, and the superintendent states that two men on one occasion, in one day, made $15 each; this was, of course, very exceptional. At one cannery no cash is paid until the cannery is closed; this is done to hold the natives and prevent them from leaving as soon as they have earned a little money.

The native conditions here are similar to those of all other localities visited. The native is naturally indolent and improvident. In former times he lived in his crude way by hunting and fishing, with a feast thrown in when a dead whale drifted to his shores. Civilization has brought new wants, to supply which he is unwilling to exert himself, so he cries starvation, in which he is supported and badly advised by white squawmen who settle among them and eke out an easy, shiftless existence.

Reports are frequently circulated by people who do not understand the situation, or, understanding it, willfully misrepresent it, implying that the canneries are a detriment to the native population; that they are taking away the food and that starvation must follow. From my experience in Alaska, in connection with the salmon question, it may be said that up to the present time I have found no truth in these reports. The canneries have not, so far, in any locality reduced the salmon so as to affect the native's winter supply; instead of working an injury, they have been, and are, a benefit to him. They bring to him better methods for obtaining his fish, and, that which is of more importance, they bring money to all who are willing to work. Were the canneries to close to-day the native would be the principal sufferer.

Judging from the appearance of the village at Afognak, and comparing it with other native communities in Alaska, there seems to be little cause for complaint. The village has rather a neat and thrifty appearance, the log and frame houses have a substantial air, there are many gardens growing potatoes and other truck, pigs and poultry seem to thrive, and several families have one or two cows. The children seen in the village appeared bright, clean, strong, and always well clad.

One of the principal half-breeds said that while there was no large amount of money in circulation and few were prosperous, still none were destitute nor in danger of becoming so. It may be remarked here that many of the natives in this district, and to the westward, died during the past winter with a disease believed by some to be grip. It is said that at Little Afognak nearly all succumbed.

The half-breeds and natives of Afognak, according to their own custom, have three recognized districts for hunting and fishing. The half-breeds of the village fish and hunt the northwestern section of the island, drained by the streams named Malinof and Paramanof; the natives of the village have the southern end of the island, which includes the reservation stream and extends to the western shore of Little Afognak Bay; the inhabitants of the latter place claim the island to the eastward of their settlement, and Marmot Island. These districts are again subdivided among the different families for hunting purposes, while the streams are open to all belonging to the district. These limits are accepted by all the inhabitants, and the intrusion of any alien is considered an abuse of their customs. It is natural, therefore, that they resent the fishing of the Afognak streams by the canneries, nor can they understand how these streams, which belong to them by tribal rights, can be closed by the Government. The situation here is the same as it is in southeastern Alaska—the native sees the value of the fish to the canneryman, and he wants the streams, not for his own use entirely, but to sell the fish to the canneries. In other words, he wants to own the streams and bar out the canneries, which is clearly untenable. To the appeal of the natives has been added that of the white men of the district.

The village of Afognak contains a number of whites, nearly all Scandinavians, married to half-breeds or natives or living with them, nearly all working in canneries

during the summer and finding life rather easy during the winter. These people have organized themselves into an association under the name of the Brotherhood of Afognak Pioneers and have taken upon themselves the regulation of municipal affairs.

In the salmon inspector's report for 1899, page 47, there is an appeal addressed to the inspector to the effect that, as the streams of Afognak are closed, they are "unable to obtain a living" and request the "permission of the Treasury Department to fish the streams of Afognak Islands." This appeal has 23 names, the nationality of which may easily be recognized. Inquiry was made in reference to the signers, and it was learned that they all belonged to the brotherhood. One is dead; 1 was injured while hunting, but does some work; 2 are Russian residents; 3 are storekeepers and well-to-do, and the remaining 16 are employed in the canneries and fisheries, some in leading positions, such as master of cannery steamer, foreman of working gang, watchman, etc. Further comment is unnecessary, as it is evident the white population desire to have the exclusive use of the Afognak streams, so they may sell fish to the canneries.

In concluding these remarks on the conditions at Afognak as they appeared to me, it is my desire to say that my sympathies are entirely with the natives, and were it possible to make any recommendations for their benefit, such would be made; it can only be asked that whatever legislation is effected a fair balance may be cast in their favor. We should not ask too much from a people who have for centuries lived on the resources which nature alone has offered and who now emerge upon a destructive civilization which holds them probably in a worse condition than in former times when they were a more primitive people. The rich furs which they formerly poured into the laps of the traders, and for which they received food and a few necessities, are gone, and the fur-trader is also going, for he can no longer fill his coffers with the catch of the grub-staked hunter. The first stage of the native's life here is over; he is now upon the second, marked on the one hand by the influence of vicious white men and on the other by the kind and gentle teachings and example of a people who sacrifice themselves for the native interests, but whom they usually do not understand. If he survives these two directly opposite influences, he may become a good citizen. It has been my experience, however, that in all parts of the world among primitive people the second stage is deadly, and that what might be called a refined civilization thrust upon a native race kills as many as the more vicious condition.

From Afognak the *Albatross* went directly to Southeast Alaska, to continue the stream and lake investigations commenced in 1897.

COOK INLET.

Alaska Salmon Association.—In the Cook Inlet district but one new cannery has been established; it is that of the Alaska Salmon Association, which was incorporated in San Francisco. This company, in 1899, purchased the C. D. Ladd saltery on the left bank and at the mouth of the Chuitna River, Cook Inlet, a good-sized stream entering the northern shore of the inlet about 6 miles above Tyonek. In the spring of 1900 this company erected a cannery on the site of the Ladd saltery and made a small hand-pack. The cannery machinery consists of 3 retorts, 1 solderer, 1 Columbia River washer, 1 cutter, and the necessary equipment for making cans by hand.

The capacity of the cannery is 500 cases per day, but next year (1901) 2 fillers and a topper will be installed, which, with the necessary hands, should increase it to 1,600 cases per day. The tin plate used is 100-pound domestic. Fish are pewed to the fish wharf and after cleaning are conveyed to the cannery.

The Chinese contract was 45 cents per case, with the usual conditions. The fishermen received $25 per month from the time engaged at San Francisco until paid off, and one-half cent each per case. The sailors were paid $40 per month when working the vessel and $50 per month when fishing, but no bonus. Full board was furnished for all except the Chinese.

The following men were employed: Thirty-nine white fishermen and trapmen, 4 white cannerymen, 12 white beachmen, and 51 Chinese. The cannery used 4 traps; leads 100 fathoms, wings 40 fathoms, pots 40 feet by 40 feet, all 6 fathoms deep; leads, 3½-inch mesh, 48 thread; wings and pots, 3-inch mesh, 60 thread; value, $1,500 each. One drag seine 150 fathoms long, 5 fathoms deep, 3-inch mesh, value $1.65 per fathom. Sixty gill nets, each 65 fathoms long, 30 meshes deep, one-third of them 9-inch mesh, one-third 6¼-inch mesh, and one-third 5¾-inch mesh; value, 65 cents per fathom. The traps were located early in the season, as follows: One near Tyonek, one between that place and Chuitna, one at the mouth of the home river, and one about 3 miles to the eastward. Heavy winds and strong currents demolished all these traps, except the one near Tyonek, before fishing began, and the latter was only saved by hard labor, which the catch did not justify. About 10 per cent of the catch was taken in traps, the remainder in gill nets.

The boats consisted of 4 scows, $250 each; 2 lighters, $150 each; 1 lighter, $50; 20 gill-net skiffs, $40 each; 5 old skiffs, $30 each; 1 yawl, $40; 1 pile-driver, $1,150.

The vessels employed were: Bark *Prussia*, 1,131 tons, crew fishermen, value $25,000, chartered; launch *King Fisher*, 7 tons, crew 3, value $5,500, owned.

The following was the output for the season:

Species.	Cases.	No. to the case.	Dates.
King salmon:			
Red	[1] 326	3.5	June 10–July 2.
White	[2] 922	3.5	Do.
Redfish [3]	3,640	12	July 1–Aug. 9.
Humpbacks [3]	5	.....	
Dog salmon	12	.....	

[1] Flats. [2] Talls. [3] Salted 44 barrels of redfish and 3 barrels of humpbacks.

Pacific Steam Whaling Company's cannery at Kenai, Cook Inlet.—Reference was made to this cannery in my former report, page 141. The buildings were erected in 1897 near the cannery of the Northern Packing Company, and the available machinery from the cannery at Coquenhena, in the Copper River delta, was installed here in the spring of 1898. The first pack was made that year.

The following cannery machinery is used: Two retorts, 4 steam boxes, 1 filler, 1 solderer, and 1 cutter; topping is done by hand. Fish are hoisted in buckets by steam to the fish-house, and when cleaned are conveyed by carts to the cannery.

All the tins are made at the cannery by hand; 100-pound tin plate is used for the bodies and tops; 46 per cent of the plate is imported.

In 1900 the following hands were employed: 40 white and 10 native fishermen, 6 white cannery-hands, 6 natives, and 60 Chinese.

They used 5 traps, averaging 1,000 feet length of lead, 240 feet length of curved wing, 30 feet by 30 feet pot, value $500 each; 20 gill nets for king salmon, each 60 fathoms long, 22 meshes deep, 9¼-inch mesh, value 65 cents per fathom, and 20 gill nets for redfish, each 60 fathoms long, 30 meshes deep, 6-inch mesh, value 65 cents per fathom.

The following boats were used: Seven lighters, $350 each; 20 gill-net boats, $40 each; 1 seine boat, $100; 3 skiffs, $25 each; 2 pile-drivers, $1,500 each.

The following vessels (owned) were employed: Gasoline *Duxbury*, 30 tons, crew 5, value $10,000; steamer *Salmo*, 28 tons, crew 6, value $10,000. Transportation by calling vessel of company.

The output in 1900 was:

Species.	Cases.	No. to the case.	Dates.
King salmon	2,400	2.7	June 1–July 10
Redfish	20,924	13	June–Aug. 10
Cohoes	1,765	8.1	July 1–Aug. 10

The Chinese contract was 42 cents per case. Fishermen received transportation and board and 1 cent each per case.

Arctic Fishing Company.—The cannery of this company at Kussilof, Cook Inlet, was fully described, together with the surrounding conditions, in my former report, pages 142–143, and the statistics for 1900 only will be referred to here.

This company employed the following hands in 1900: Forty-five white fishermen, 10 native fishermen, 10 white cannery-hands, and 100 Chinese. Eight traps were used, with leads from 100 to 700 feet long, pots 30 feet by 30 feet, depth at pots 30 feet, average value $1,000; 30 king-salmon gill nets each 60 fathoms long, 22 meshes deep, 9½-inch mesh; 30 redfish gill nets, each 60 fathoms long, 28 meshes deep, 6⅛-inch mesh, value 65 cents per fathom. There were used 3 sail lighters, $450 each; 7 trap scows, $50 each; 20 gill-net boats, $40 each; 2 Columbia River boats, $200 each; 6 skiffs, $30 each; 2 pile-drivers, $1,500 each.

The machinery consisted of 6 retorts, 2 fillers, 2 toppers, 1 solderer, 1 cutter, and 1 can-maker; 75 per cent of the tins are made at the cannery of 100-pound tin plate, 60 per cent of which material is imported. Fish are hoisted in tubs to the fish-house by steam and, when cleaned, are conveyed in cars to the cannery.

The Chinese contract was 45 cents per case, with the usual conditions. The fishermen received $50 for the run and 1 cent per case, with full board.

The following vessels (owned) were employed:

Class and name.	Tons.	Crew.	Value.
Ship Centennial	1,138	Fishermen.	$30,000
Steamer Jennie	69	6	30,000
Steamer Reporter	26	3	10,000
Launch Arthur	5	2	1,800

The following was the output in 1900:

Species.	Cases.	No. to the case.	Dates.
King salmon	6,169	3	May 26–Aug. 10
Redfish	22,185	13	May 28–Aug. 12
Cohoes	5,427	12	July 15–Aug. 12

PRINCE WILLIAM SOUND AND COPPER RIVER.

This district, with the canneries, was fully described in my former report, pages 129–139. Since then the cannery at Coquenhena has made one more pilgrimage. It was dismantled in 1897, and, as previously noted, the available machinery was installed in the Pacific Steam Whaling Company's cannery at Kenai, Cook Inlet.

The Pacific Packing Company, at Odiak, for the season of 1900 employed 1 doctor, 60 white fishermen, 10 white cannery and beach hands, 6 natives, and 60 Chinese. It had 1 drag seine 250 fathoms long, 120 meshes deep, 2½-inch mesh; value, $1.50 per fathom; 38 gill nets, each 350 fathoms long, 30 meshes deep, 6⅛-inch mesh; value, 65 cents per fathom. The boats were 2 lighters, $400 each; 3 house scows, $400 each; 33 Columbia River boats, $200 each; 2 seine boats, $200 each; 6 skiffs, $25 each.

The following vessels were employed:

Class and name.	Tons.	Crew.	Value.	Owned or chartered.
Bark Kate Davenport	1,175	(1)	$10,000	Chartered.
Steamer Pacific	31	6	15,000	Owned.
Steamer S. B. Matthews	164	6	14,000	Do.
Steamer Susanna	18	4	8,000	Do.

[1] Fishermen.

The following was the output of canned salmon in 1900, none being salted:

Species.	Cases.	No. to the case.	Date.
King salmon	473	4½	May 9–June 12
Redfish	35,049	11½	May 9–Aug. 4
Humpbacks	3,888	22½	July 6–Aug. 2

The Chinese contract was 42 cents, with the usual conditions. The fishermen received $60 for the run and 4 cents per boat of two men for redfish, 10 cents for king, and $10 per thousand for humpbacks, with full board.

The cannery machinery consists of 8 retorts, 2 fillers, 2 toppers, 2 solderers, and 1 cutter. The tins are all made at the cannery, by hand, of 100-pound domestic plate for bodies and 95-pound tin for tops.

The fish are pewed to the fish-house and, after cleaning, are conveyed by cars to the cannery.

The Pacific Steam Whaling Company, at Orca, employed, in 1900, 60 white fishermen, 13 white cannery-hands, 2 natives, and 60 Chinese.

They used 2 drag seines, each 120 fathoms long, 40 meshes deep, 3-inch mesh; value, $1.50 per fathom; 30 gill nets, 400 fathoms long, 28 meshes deep, 6 to 6¼ inches mesh. The boats used were 5 house scows, $400 each; 30 Columbia River boats, $200 each; 2 seine boats, $200 each; 8 skiffs, $25 each; 1 pile-driver, $200.

The following vessels were employed:

Class and name.	Tons.	Crew.	Value.	Owned or chartered.
Ship America	1,908	(1)	$55,000	Chartered.
Steamer Thlinket	90	4	10,000	Owned.
Steamer Wild Cat	104	4	10,000	Do.

[1] Fishermen.

The following was the canned output in 1900, none being salted:

Species.	Cases.	No. to the case.	Date.
King salmon	369	4.2	May 7–June 7
Redfish	28,501	12	May 7–July 22
Humpbacks	1,718	28	July 20–July 24

The Chinese contract was 42 cents per case, with the usual conditions. The fishermen received $15 per month throughout the season, full board and transportation, and 4 cents per boat for redfish, 10 cents for king salmon, and $5 per thousand for humpbacks.

The cannery machinery consists of 4 steam boxes, 2 retorts, 1 filler, 1 solderer, and 1 cutter. Fish are pewed to the fish-house and, after cleaning, are passed directly to the cutter from the draining tubs. They use 100-pound tin plate for bodies and tops, all imported. All the tins are made at the cannery.

The redfish used in these canneries are nearly all taken from the Copper River delta. All the humpbacks and a few redfish come from the Prince William Sound streams. A description of the locality, time of runs, and other information is given in my former report.

CHILKOOT STREAM, SHOWING NATIVE FISHING PLATFORMS IN CURRENT.

SOUTHEASTERN ALASKA.

Since my former report eight new canneries have been built in this district, one of which made its first pack in 1899 and the remainder during the present season (1900). During the same period one has been dismantled, that of the Baranof Packing Company at Redfish Bay, which was sold to the Alaska Packers Association and moved to the Egagak, and one was in course of construction, in 1900, at Bartlett Bay, which will be operated in 1901. The season of 1901 promises to see many new canneries in Alaska, a number of which will locate in this district.

Western Fisheries Company.—A company under this title, organized at Portland, Oreg., built a cannery in the spring of 1900 at the head of Dundas Bay, which is on the northern side of the junction of Cross Sound and Icy Straits. The cannery is one of the smaller ones and has a capacity of 300 cases per day, made largely by hand.

In 1900 this cannery employed 9 white fishermen, 26 native fishermen, 5 white cannery-hands, 20 native men, 6 native women, and 30 Chinese. The record of the native men includes those to whom gear was furnished and from whom the catch was purchased. They used one purse seine 150 fathoms long; 6 drag seines—length, 2 of 140 fathoms, 1 of 100 fathoms, 1 of 80 fathoms, 1 of 60 fathoms, and 1 of 50 fathoms—valued at $1.50 per fathom; 4 gill nets of 150 fathoms each, valued at 65 cents per fathom. There was 1 lighter, $250; 5 seine boats, $75 each; 4 gill-net boats, $50 each; 2 Columbia River boats, $100 each; 1 dory, $50; 1 skiff, $50.

The transportation was by regular freight steamers. The following cannery steamers were used: Steam tug *Favorite*, 7 tons, crew 3, value $2,000, chartered; steam tug *Beaver*, 19 tons, crew 5, value $5,500, owned.

The following was the output in 1900, none being salted:

Species.	Cases.	Number to the case.	Date.
King salmon	60	4.5	Sept. 1–Sept. 30
Redfish	6,130	8 to 12	June 28–Aug. 25
Cohoes	977	7.5	July 30–Sept. 20
Humpbacks	1,866	18	July 10–Aug. 10
Dog salmon	4,760	6.5	July 15–Sept. 20

The Chinese contract was 38 cents for 1-pound talls, 40 cents for half-pound flats, and 42 cents for 1-pound flats, with the usual conditions. The white fishermen received $40 to $60 per month, with transportation and board. Fish were purchased at the following rates: King salmon, 10 cents; cohoes, 6 cents; redfish, 5 cents; dog salmon, 2 cents; humpbacks, 1 cent.

The following are the numbers of fish taken and the localities where found: 275 king salmon off Hooniah; 66,901 redfish in Dundas Bay, Taylor Bay, Surge Bay, Cape Spencer, Thakanis Bay, Soapstone Point, Excursion Inlet, and Glacier Bay; 8,596 cohoes, scattering on the redfish grounds; 35,383 humpbacks at Port Althrop, Soapstone Point, and Excursion Inlet, and 29,803 dog salmon in Dundas Bay.

Pyramid Harbor Packing Company.—This cannery, the fisheries, and the general locality were described in my former report, pages 125 to 128, so that only the statistics for 1900, together with references to features omitted or changes made, will be given here. The canning machinery consists of 6 retorts, 2 fillers and 1

spare one, 2 toppers, 2 solderers, 1 cutter, and 1 can-making set. All tins are made at the cannery of 100-pound tin plate for bodies and 95-pound for tops; 60 per cent of the plate is imported. It has a daily capacity of 1,600 cases, but this amount is rarely attained. The pack of this cannery is the choicest in Alaska; it is mostly for export, is made with great care, and has only about ½ per cent of do-overs. It is very clean and free from the unpleasant odors noticed in many packing houses.

The fish are pewed from boats to a car operated by a cable and steam, traveling on an inclined plane from the water's edge to the fish-house, and the cleaned fish are passed from the draining tubs direct to the cutter. The gurry is carried with a stream of water in a wide trough under the fish-house into the bay. The Chinese contract was 42½ cents for machine-filled cans, with the usual conditions. The boss received $50 a month and his lay, and the tester $250 for the season. The fishermen had $50 for the run and 4 cents per fish for each boat of two men and full board. About ten natives were employed as boat-pullers, who shared in the gill-net catch. Klootchmen employed in the cannery received $1.25 per day.

The cannery purchased fish from about 224 Chilkat and Chilkoot Indians, paying 10 cents for redfish, though formerly 6 and 8 cents were paid. The Chilkats delivered at the cannery, while the cannery steamers called for the Chilkoot fish.

The following redfish were delivered by the Chilkat Indians: In 1898, 11,156 during August; in 1899, from July 19th to August 31st, 21,000; in 1900, from July 25th to September 1st, 47,967.

By the Chilkoot Indians: In 1898, July 12th to August 22d, 99,660; in 1899, from July 10th to August 13th, 148,896; in 1900, from July 12th to August 22d, 169,107.

The cannery obtains its fish from Chilkat and Chilkoot inlets and rivers and from Taku Inlet. King salmon run at Taku from May 25 to June 30; at Chilkat, from June 10 to July 10, but they are not abundant. A few straggling redfish appear at Chilkat about June 20, but they are not found in large numbers until the last of June or early in July. They are plentiful then until the middle of August and straggle with cohoes until the last of September. The run in Chilkoot begins earlier and closes earlier than in the Chilkat. (In my former report the names became transposed and this was wrongly stated on page 128.) A good run for about forty-five days is usually looked for. The redfish are called sock-eye, the name used for this species in Puget Sound and on the Columbia; and it was noticed that with the advent of canneries backed by capital from that district the name sock-eye is becoming more common in Alaska. Cohoes are called kluks, which is the Indian name and the same as that used at Killisnoo. They run in Chilkat Inlet from about the middle of August to early in October, possibly later, and are quite abundant in September. There are very few humpbacks in Chilkat, but it is said that they are quite abundant in Chilkoot. Dog salmon straggle through the season and some years are abundant in September.

The pack of this cannery is in redfish; the king salmon and cohoes are incidental and the humpbacks and dog salmon are not used. The first steelhead ever seen in this locality was taken this year. The only sturgeon ever seen was mentioned in my former report. No shad have been seen. There are many Dolly Varden trout and some very large halibut. The cannery uses gill nets exclusively, while the Indians fish the rivers with gaffs and nets, the latter about 60 fathoms long.

The following are the statistics of the Pyramid Harbor cannery for 1900:

Hands employed: 92 white and 10 native fishermen; 224 natives from whom fish were purchased; 12 white cannery-hands, 16 Klootchmen, and 86 Chinese.

Fishing gear: 56 gill nets for redfish, each 300 fathoms long, 28 meshes deep, 6½-inch mesh; 14 gill nets for king salmon, each 180 fathoms long, 30 meshes deep, 8½-inch mesh.

Boats, lighters, etc.: Three lighters, $400 each; 56 Columbia River boats, $200 each; 3 skiffs, $25 each, and 1 pile-driver, $1,000.

The following vessels (owned) were employed in 1900: Steamer *Elsie*, 37 tons, crew 4, value $16,000; ship *Two Brothers*, 1,263 tons, crew fishermen, value $35,000.

The following was the 1900 output:

Species.	Cases.	No. to the case.	Date.
King salmon:			
Red	[1]2,255	3.5	May 29–June 30.
White	[2]977	3.5	Do.
Redfish	51,856	11	July 9–Sept. 1.
Cohoes	513	7.5	Aug. 20–Sept. 1.

[1] Flats. [2] Talls.

CHILKOOT INLET.

Chilkoot Inlet is the arm at the head of Lynn Canal east of Chilkat and is separated from that inlet by a long, narrow peninsula terminating in Seduction Point.

Chilkoot Packing Company.—At the head of Chilkoot Inlet is the cannery of the Chilkoot Packing Company, organized at Aberdeen, Wash., with a capital of $20,000. This company built their cannery in April, 1900, at the head of the inlet, on the northern shore, in a small bend immediately outside of the line where the river flats impinge upon the shore line. The promoters of this cannery formerly owned a cannery at Grays Harbor, Washington.

The Chilkoot cannery in 1900 had a daily capacity of 200 cases, but this might be doubled. The plant consists of 2 steam boxes, 2 retorts, 1 soldering machine, and 1 cutter. It is one of the smaller canneries and makes a hand pack. For the season of 1901 they expect to have fillers and toppers in operation.

Nine thousand cases of cans were made by hand at the cannery and the rest were purchased; 95-pound tin plate was used, all domestic. Fish are pewed from boats to fish-house and when cleaned are carried to the cannery on a conveyer of an endless chain of buckets. Transportation is by regular freight steamers.

The Chinese contract was 42½ cents, with the usual conditions. Fishermen received $25 per month from the time of departure from Puget Sound to date of return, with full board, transportation, and 5 cents for each redfish per boat of two men. The cannery paid the Indians 10 cents for redfish taken with their own gear and 8 cents for redfish taken with cannery boats and gear.

They used seines and gill nets and fished from the head of the inlet to Haines Mission for redfish and in Berners Bay for cohoes and dog salmon, though all the species occur in the inlet; scattering king salmon sometimes appear. A few redfish have been seen as early as June 15. Trout are abundant and halibut and flounders are not uncommon. The Chilkoot redfish run quite large. We weighed 33 taken

in the ship's seine, and they averaged 8¼ pounds; 30 from the cannery bin averaged 7½ pounds. The following record of steelheads may be of interest: August 20, 1 steelhead; August 25, 3 steelheads, length 28 inches, weight 9½ pounds; August 26, 2 steelheads, length 28 and 32 inches, weight 10 and 13½ pounds; August 29, 3 steelheads, length 26, 28, and 31 inches, weight 9½, 10½, and 13½ pounds; September 4, 4 steelheads; September 8, 2 steelheads.

In 1900 the cannery employed 24 white and 8 native fishermen and purchased from 16 natives; 9 white cannery-hands, 17 natives, and 28 Chinese.

It used 1 purse seine, 160 fathoms by 20 fathoms, 3¾-inch mesh, value $1,400; 16 gill nets, each 270 fathoms long, 25 meshes deep, 6¼-inch mesh, value 65 cents per fathom; 2 Columbia River boats, $90 each, and 1 skiff, $25.

The following cannery steamers were used: Steamer *Estella*, 20 tons, crew 3, value $3,500, owned; launch *J. R. Roberts*, 9 tons, crew 2, value $3,000, chartered.

The following was the output of canned salmon, none being salted:

[Half-pound tins are packed in cases of 48 tins, but are reckoned in cases of 48 pounds.]

Species.	Cases.	No. to the case.	Date.
Redfish	[1] 9,022 [2] 4,098 [3] 828	8.3	June 30–Sept. 7.
Cohoes	[1] 574 [3] 170	8	Sept. 7–Sept. 15.
Dog salmon	[1] 158	8	Sept. 16–Sept. 25.

[1] One-pound talls. [2] One-pound flats. [3] One-half pound flats.

CHILKOOT RIVER AND LAKE.

The northwestern end of Chilkoot Inlet terminates in a narrowing, V-shaped indentation, which receives at its head the waters of Chilkoot River. The indentation is about one-half mile wide at the outer end by three-fourths mile in length, and at low water is an uncovered flat, with a shallow boat channel meandering through it, which carries the river discharge. At the apex of the V is the river mouth, which at this point is contracted to about 100 feet by a point making from the western shore. Within the point is a tidal basin about 100 yards wide and one-fourth mile long, which extends to the foot of the rapids at the head of tide water. From here the stream first curves gently to the northward and then to the westward until it reaches the lake, three-fourths mile distant, having an average width of about 125 feet. With the exception of a length of about one-fourth mile from the lake, where, however, the current flows with considerable velocity, the entire river from tide water is a rapid of gentle fall. At the middle of this length, on the western shore, is a summer village of Chilkoot Indians, who fish the stream and, it is said, the lake also.

The bottom of the stream is rocky and bowldery. The right bank is steep to a narrow grassy shelf which merges into rolling, densely wooded hills; the left bank is steep and wooded, with grassy recesses, and rises rapidly to the precipitous mountain masses. The rapids are all staked off, each stake indicating the fishing-place allotted to an Indian family, which is handed down from one generation to another and jealously guarded against intruders. During the fishing season the Indians build platforms over or secure canoes on their claims, and from either conduct the fishing,

by means of a large iron barbless hook secured to the end of a stout pole. The impaled fish is thrown into a box alongside of the fishermen. At one point of the rapids runways have been constructed by piling rocks in parallel lines and confining the water to narrow channels. In these runways fyke-net-shaped traps are arranged to be raised or lowered to meet the level of different stages of the water. It is said they do not work very well, but to my eyes it looked as if few fish could pass without being trapped. It is probable that short nets are also used in the rapids.

Plan of Chilkoot lake and stream.

The lake has an extreme length of $2\frac{1}{2}$ miles in a northwest and southeast direction, with an average width of 1 mile. It lies in a basin nearly surrounded by lofty, precipitous mountains reaching an altitude of 4,000 to 5,000 feet, and is largely fed by cascades and streamlets from the melting snows and glaciers. There is one feeder worthy of the name of stream which enters the lake at the extreme northwestern

end through a narrow valley leading to a glacier. We had no means for reaching this stream, but at a distance it appeared as if there were considerable areas of flat land around its mouth. The banks around the southern end of the lake, and on either side as far as could be seen, are steep and rocky, and the bottom bowldery, shelving rapidly to deep water. The spawning-grounds are probably around the feeder at the head of the lake where, it is said, the bottom is sand and gravel. The water is quite cold and whitish, like all glacial waters.

The only probable site for a hatchery is near the large feeder, where water by gravity and ripe fish could be obtained. The water would probably have to be filtered, and the question of freezing might be an important one, and can only be solved by a series of observations over an extended period.

KILLISNOO.

The Alaska Oil and Guano Company's works at Killisnoo were again visited. They were described in my former report, pages 121 to 125. There has been no change in the plant since our previous visit. The large trap in Hootznahoo Inlet has been abandoned, as the results were not commensurate with the expense involved. The herring taken in this locality are very rich in oil, and when salted have attracted the attention of the eastern market. A large order was placed with this company for the salt product, which, however, they were unable to fill. Fishing commenced this year on May 26, a date much earlier than heretofore.

There were employed 20 white and 10 native fishermen; for factory and beach hands 27 whites, 38 natives, and 13 Chinese. Their rate of pay is given in my former report, page 122. The company used two purse seines, 150 fathoms by 15 fathoms, value $1,200 each; one drag seine, 250 fathoms by 20 fathoms, $2,000; 3 lighters, $800 each; 8 seine boats, $125 each; 6 strike boats, $75 each; 20 dories, $25 each.

The following vessels were employed on the fisheries. Their crews are included in the numbers given under the hands employed.

Class and name.	Tons.	Crew.	Value.	Chartered or owned.
Steamer Dolphin	60	18	$10,000	Chartered.
Steamer Favorite	42	16	5,000	Owned.
Launch Louise	5	3	3,000	Do.

The following was the output in 1898, 1899, and 1900:

1898.—45,240 barrels of herring, making 165,500 gallons of oil and 886 tons of guano; from June 27 to November 19.

1898.—Salted 1,300 half-barrels of herring and 25 half-barrels of humpback bellies.

1899.—36,800 barrels of herring, making 128,000 gallons of oil and 714 tons of guano; from July 5 to November 5.

1899.—Salted 1,650 half-barrels and 200 barrels of herring, and 31 half-barrels of humpback bellies.

1900.—60,300 barrels of herring, making 172,000 gallons of oil and 1,194 tons of guano; from May 26 to November 5.

1900.—Salted 185 half-barrels and 100 barrels of herring, 5 barrels of king salmon, 8 half-barrels and 210 barrels of redfish, and 523 half-barrels of humpback bellies.

CHILKOOT STREAM, SHOWING NATIVE FISH RUNS AND TRAPS IN CURRENT.

TAKU INLET.

Taku Packing Company.—A company under this title was organized in Astoria, Oreg., by some of the stockholders of the Alaska Fishermen's Packing Company, Nushagak, with a capital of $20,000, and in the spring of 1900 a cannery was built on Taku Inlet. The construction of the buildings was commenced March 28, and the plant was ready for operation on May 17. It is located on the western shore of Taku Inlet, 2½ miles west by north from Jaw Point, on the northern side of a small bight (Sunny Cove), which receives the waters of a small stream.

It is a small cannery, making a hand pack, and has a daily capacity of 250 cases, with expectations of making from 15,000 to 18,000 cases a year. The capacity of the cannery will be increased in 1901. It has 1 steam box, 1 retort, 1 solderer, and 1 hand cutter. The cans, which were purchased and carried to Alaska, were made of 95-pound tin plate. Transportation is by regular freight steamers, which call upon notification. The Chinese contract was 42 cents for talls and 44 cents for flats, with the usual conditions. The fishermen were transported each way, had full board, received $80 for the season, and 5 cents for redfish and 10 cents for king salmon per boat of two men. The native cannery-hands were paid $2 per day.

This year the fishing was confined to Taku Inlet and most of the fish were obtained near the mouth of the river, described in my former report, page 126. It is expected, however, in the future to expand the fisheries and include neighboring streams. Fishing in the inlet is difficult on account of ice pouring from the glaciers, and, as there are no seining beaches, it is confined to gill nets.

According to the cannery data king salmon begin to run in Taku Inlet May 8 and continue to June 26. The Pyramid Harbor cannery, which has fished here for many years, gave the dates of the king salmon runs as May 25 to June 30. It is probable that the time depends upon the movements of the ice, and the earlier date may be for the first arrivals whose numbers are insufficient for a large cannery. Of the early run 15 per cent are white-meated, and this proportion increases until the latter part of the run, when about 30 per cent are found in this condition. One king salmon was taken weighing 64 pounds. The first arrivals of the redfish were noted on June 20, but they did not come in sufficient numbers for canning until July 1; they then continued to August 12.

Cohoes run from August 1 to October 1, and dog salmon are noticed scattering throughout the season, but are most abundant in August. Steelheads are quite abundant and were first noticed from July 15 to August 1. At the time of our visit, August 25 and 26, they formed about 10 per cent of the catch. Dolly Varden trout are numerous, and there are a few halibut, but no shad or sturgeon.

The following are the statistics:

Hands employed: Thirty white and 14 native fishermen, 7 white and 2 native cannery-hands, and 19 Chinese.

Fishing gear: Fifteen redfish gill nets, each 150 fathoms long, 35 meshes deep, 6¼-inch mesh; and 22 king-salmon gill nets, 150 fathoms long, 22 meshes deep, 9½-inch mesh, value 65 cents per fathom.

Boats, lighters, etc.: 2 lighters, $225 each; 1 fish scow, $150; 15 gill-net boats, $60 each; 2 dories, $25 each. Launch *Fawn*, 5 tons, crew 2, valued at $1,000, owned.

The output was as follows, none being salted:

Species.	Cases.	No. to the case.	Date.
King salmon:			
Red	[1] 3,150		
Pink	[1] 454	2.8	May 17–June 26
White	[1] 771		
Redfish	[1] 5,818	9	July 5–Aug. 12
	[2] 830		
Cohoes	[1] 3,227	7	Aug. 1–Sept. 15
Dog salmon	[1] 2,472	6.5	Aug. 15–Sept. 25

[1] Talls. [2] Flats.

PORT SNETTISHAM.

Taku Fishing Company.—This company, with a capital stock of $15,000, said to be owned in San Francisco, but with home address at Portland, Oreg., commenced the construction of a cannery on March 4, 1900, and had the plant ready for operating June 4. It is located on the southern side of the entrance to Port Snettisham, in the first bend within the southern entrance point, 2 miles east of Point Styleman. It is a small cannery, making a hand pack, with a daily capacity of 300 cases, and an outfit for about 12,000 to 15,000 cases per season. It has 3 retorts, 1 solderer, and 1 hand cutter. All cans are made by hand at the cannery, of 95-pound domestic tin.

The Chinese contract was 43 cents for hand-filled cans, with the usual conditions. The locality has not heretofore been considered a favorable location; hence no fishermen's contracts could be made and they were paid wages throughout the season. The white fishermen were transported and, with the natives, received from $40 to $65 per month and board. The cannery paid 7 cents each for redfish and 50 cents per hundred for humpbacks. King salmon were obtained from Taku Inlet and redfish from Port Snettisham. Humpbacks were largely from Limestone Inlet and from small streams near the cannery.

Employees: 16 white and 20 native fishermen, 4 white cannery-hands, 25 Chinese.

Fishing gear: Four gill-nets for king salmon, each 150 fathoms long, 20 meshes deep, 9¼-inch mesh; 14 gill-nets for redfish, each 150 fathoms long, 30 meshes deep, 6½-inch mesh—all valued at 65 cents per fathom. The cannery had 1 purse seine, 165 fathoms long, 300 meshes deep, 3½-inch mesh, value $400, and 3 drag seines averaging 100 fathoms long, 5 fathoms deep, and 3½-inch mesh, value $1.50 per fathom.

Boats, etc.: One lighter, $500; 3 seine boats, $50 each; 3 Columbia River boats, $150 each; 9 gill-net boats, $50 each. The following launches were also used: *N. & S.*, 10 tons, crew 2, valued at $1,800, owned; *Pescadero*, 4 tons, crew 1, value $600, owned. The transportation was by regular freight steamer.

The following was the output:

Species.	Cases.	No. to the case.	Date.
King salmon:			
Red	454	3	June 1–June 20
White	97	3	Do.
Redfish	2,542	9	July 9–July 27
Cohoes	756	7	Sept. 1–Sept. 24
Humpbacks	3,593	21	July 25–Aug. 16
Dog salmon	2,016	7	July 9–Sept. 24

WRANGELL NARROWS.

Icy Strait Packing Company, Petersburg.—This company, incorporated in the State of Washington, is organized from the stockholders of the Quadra Packing Company, who, to expand their work in Alaska, purchased the saltery interests in Bartlett Bay, near Icy Strait, intending to build a cannery at that point during the season of 1899. Circumstances arose which made it inexpedient to carry out the Bartlett Bay project at the time, and, attention having been directed to a site in Wrangell Narrows for a cannery, fishery, sawmill, etc., work was commenced on this plant in the summer of 1899, when a small sawmill was set up, a substantial steamer wharf built, and a warehouse, store, and residence completed. It is located inside of the northern entrance to Wrangell Narrows on the southeastern shore, about a mile above Turn Point and an equal distance from the open waters of Frederick Sound. The position is an excellent one, as it is convenient to several very good fisheries, and all steamers pass close to the wharf on their regular routes to and from Alaska ports. A town site has been recorded, a post-office and an express office established under the name of Petersburg, and an Indian village has sprung up close by. During the winter of 1899–1900, and while the building operations were in progress, the company engaged in the herring and halibut fisheries. Of the former, during the months of September and October, 1,500 barrels were salted, mostly taken from Wrangell Narrows. The halibut were shipped on ice to Puget Sound. As this may become an important industry, it will be referred to under another heading.

In the spring of 1900 the cannery building, warehouse, bunk-house, etc., were erected and the canning machinery installed. Situated on the steamer route, the surroundings have been made attractive by gardens, plank walks, bridges, etc., and the buildings are substantial, well arranged, and very clean.

Fish are pewed from boats or lighters to the fish-house on the end of the wharf, which is well arranged, clean, and clear of bad odors. After cleaning, the fish are passed directly from the draining tables to the cutter. As the pack is made by hand, the severed fish are carried from the cutter to the filling tables, which are arranged for 64 fillers. Klootchmen do most of this work and receive 6 cents a case for filling. The cans then go to the washer, after which the floats are put in and the tops put on by Chinese; they then pass to the crimpers, and in succession to the acid bath, solderer, etc.

The cannery machinery consists of 5 steam boxes, 3 retorts, 1 cutter, 1 washer, 2 cappers, 2 crimpers, and 1 solderer. They have a good supply of hand tools, small lathe, drill press, etc., and a well-equipped cooperage and box factory. 14,500 cases of cans were purchased; the remainder were made at the cannery. The tin was 100-pound plate for the tops and bodies, both domestic and imported, but the proportion of each could not be ascertained. The cannery as installed at present has a daily capacity of 1,000 cases, hand-filled. It is probable that filling machinery will be introduced, though it is believed that a hand-filled pack is preferred.

The Chinese contract was 45 cents, with the usual conditions. The fishermen received $35 per month, board and allowances, which brings the average up to about $50 per month. Native fishermen receive the same as whites if they complete the season. Fish were purchased at the lowest rates for which they could be obtained. The native work this season was very satisfactory.

The fisheries of this cannery were conducted over such a wide area and in such an irregular way that no accurate stream data is available. The crews were moved from place to place, as seemed to offer the best facilities and the most fish. Points 130 to 140 miles distant were reached for fish to supply the cannery, and much enterprise was exhibited on this work. The following streams were fished, and the numbers taken by this cannery, where known, are given: Taku Inlet; North Stream, Stikine Delta; Blind River, Wrangell Narrows; North End, Wrangell Narrows; head of Duncan Canal; Redfish Bay, 34,000 redfish; Freshwater Bay, 25,000 redfish; Basket Bay, 30,000 redfish; Sitkoh Bay, 30,000 redfish; North Bay of Pillars; South Bay of Pillars, 6,500 redfish; Tebenkof Bay, 7,000 redfish; Shipley Bay; Rocky Straits, 25,000 redfish; Red Bay, 30,000 redfish.

In addition to the plant at Petersburg this company operated salteries in conjunction with it at Taku Inlet, Shipley Bay, and Bartlett Bay, and also on the hulk *Blanche*, and as the men and material are interwoven with the cannery operations these salteries will be referred to and the statistics given as a whole.

Bartlett Bay saltery is located on the abandoned cannery site of the Bartlett Bay Packing Company, once the property of the Alaska Packers Association, which, as previously noted, was the location first selected by the Icy Strait Packing Company for their cannery. During the season of 1899 two white fishermen, on the part of the new company, prospected the place for fish and salted 200 barrels of salmon, which were marketed from Petersburg.

During the season of 1900 regular salting operations were conducted here by the Icy Strait Packing Company, and at the same time buildings were erected for a cannery, in which machinery will be installed in the spring of 1901. The cannery will be operated that season.

Shipley Bay saltery, which was formerly operated by Walter Kosmikoff and located at the head of that bay (see my former report, p. 109), was acquired by the Icy Strait Packing Company and operated during the season of 1900.

Taku Inlet saltery was built in 1897 by the present Alaska manager of the Icy Strait Packing Company on Taku Point, near the head of the inlet of that name. In 1898 and 1899 it was operated by the Quadra Packing Company, and in 1900 by a large force, with gear, from the Petersburg establishment.

The hulk *Blanche* was used by the Icy Strait Packing Company for salting herring, and was moved in the narrows from point to point as occasion required, though generally located off Blind River. The company fitted out to salt 4,000 barrels by the end of the year. The herring come to Wrangell Narrows in July, and are found in that vicinity until February.

The following are the statistics of the Icy Strait Packing Company, and in it are included the men, boats, gear, etc., employed in the salteries at Bartlett Bay, Shipley Bay, Taku Inlet, and on the hulk *Blanche*.

Hands employed: 34 white and 24 native fishermen; 10 white and 42 native cannery-hands, and 50 Chinese.

Fishing gear: Five purse seines, each 120 fathoms long, 10 fathoms deep, and 3-inch mesh; value, $3 per fathom. Five drag seines, each 120 fathoms long, 6 fathoms deep, and 3-inch mesh; value, $1.50 per fathom. Two drag seines (for herring), 180 fathoms long, 15 fathoms deep, and 2-inch mesh; value, $3 per fathom.

NATIVE VILLAGE NEAR CANNERY OF ICY STRAIT PACKING COMPANY, NORTH END OF WRANGELL STRAIT.

Gill nets: King salmon, each 50 fathoms long, 25 meshes deep, and 9-inch mesh; redfish, 50 fathoms long, 40 meshes deep, and 5¾-inch mesh; cohoes, 75 fathoms long, 30 meshes deep, and 7-inch mesh (120 nets in all; value, 65 cents per fathom).

Boats, lighters, etc.: 1 cargo lighter, $850; 12 seine boats, $100 each; 12 gill-net boats, $50 each; 12 seine-boat tenders, $35 each; 4 skiffs, $20 each; 1 pile-driver, $500.

The following vessels (owned) were employed:

Class and name.	Tons.	Crew.	Value.
Steamer White Wings	34	6	$7,000
Steamer Annie M. Nixon	18	6	6,000
Steamer (stern. pad.) Gypsy Queen	58	.....	6,000
Hulk Blanche	107	(1)	4,500
Scow Elliott	43	(1)	1,000

[1] Fishermen.

The output of the cannery consisted of—

Species.	Cases.	No. to the case.	Date.
Redfish	[1] 8,625 [2] 1,316	15	July 1–Aug. 20
Cohoes[3]	[1] 500 [2] 1,000	7	Sept. 10–Oct. 10
Humpbacks	[1] 10,000	20	July 20–Sept. 15
Dog salmon	[1] 4,800 [2] 3,700	8.5	Aug. 15–Oct. 30

[1] Talls. [2] Flats. [3] Salted 100 barrels cohoes, running 27 to the barrel.

The Bartlett Bay saltery in 1899 salted 200 barrels of redfish. In 1900 it salted 530 barrels of redfish, 45 to the barrel, June 25 to August 7; 120 barrels of cohoes, 30 to the barrel, August 20 to September 30.

The Shipley Bay saltery in 1900 salted 200 barrels of redfish, 50 to the barrel, June 27 to August 14.

The Taku Inlet saltery in 1898 salted 140 barrels of king salmon and 12 barrels of white king-salmon bellies. In 1899 it salted 400 barrels of king salmon, 12½ to the barrel, and 12 barrels of white king-salmon bellies, May 10 to June 25. In 1900 it salted 400 barrels of king salmon, 12½ to the barrel, and 12 barrels of white king-salmon bellies, May 7 to June 25.

On the hulk *Blanche* in 1899 there were salted 1,500 barrels of herring, September 15 to October 31; in 1900, 1,000 barrels of herring, August 1 to October 3.

Pacific Coast and Norway Packing Company, Wrangell Narrows.—This is a company chartered in Minnesota, with main office at Minneapolis, and said to be incorporated for $1,000,000, of which, however, a very small portion only is reported to have been subscribed. It is a new organization, and this year was prospecting for a cannery site on Wrangell Narrows, or in that vicinity. It is expected to build a cannery in the spring of 1901 and make a pack that season, but none of the details have yet been considered. This season a floating saltery outfit was operated and salmon and herring were salted. Later the halibut industry is to be examined.

The following are the statistics, as far as they could be learned:

Men employed: 16 white and 8 Japanese fishermen and 2 Japanese cooks.

Outfit: 1 herring seine, 130 fathoms long, 40 feet deep, 1½-inch mesh, value $800; 1 herring seine, 110 fathoms long, 30 feet deep, 1½-inch mesh, value $600; 2 gill nets, 75 fathoms long, 30 meshes deep, 7-inch mesh, value 65 cents per fathom; 2 seine boats, $180 each; 2 dories, $30 each; 3 skiffs, $20 each.

The vessels were the steamer *Neptune*, 176 tons, crew 10, value $10,000, owned; house scows *Ike*, value $1,000, owned; *Joe*, value $1,000, owned.

This outfit reached Wrangell Narrows August 20, and has been operating in the vicinity of Blind River. To September 5th, 250 barrels of herring and 8 barrels of cohoes had been salted. The party was fitted out to salt 3,000 barrels of herring. One of the house scows is fitted up as a cooper shop and the other as a bunk-house.

The Royer-Warnock Packing Company.—This firm hails from San Francisco and located a cannery in southeastern Alaska in the spring of 1900. The site is that of the Buck saltery, in Beecher Pass, which connects Duncan Canal with Wrangell Narrows. The cannery is on the northern side of the pass, immediately within the southeastern point of the largest and easternmost of three islands which lie in the pass just south of Hood Point, with which they are connected at low water.

The cannery is a very small plant, the old saltery building having been utilized in the so-called main building, and is without appliances usually found in a cannery of simplest form. It is believed that under present conditions an output of 25 cases a day would tax the efforts of the cannery. On the day of my visit 900 fish were received, and it was said that it would take from Thursday morning until Sunday to pack them. The superintendent stated that machinery would be introduced next year (1901), so that a season's pack of 25,000 cases could be made. In this event new buildings will have to be erected, as the present ones are mere shacks.

The pack was truly made by hand. The fish were cut in sections with an ordinary butcher's knife, and the cans filled, capped, crimped, and soldered by hand. All cans were purchased; weight of tin plate unknown. There were no fishermen; all fish were purchased, and for them 6 cents to 8 cents were paid. There was no Chinese contract; the Mongolians employed were paid $35 per month and received board and transportation.

The cannery employed 2 white men, 10 Japanese, and 1 Chinese. It had 2 seines, each 100 fathoms by 5 fathoms, value, $1.50 per fathom; 1 gill net, 100 fathoms by 30 meshes, 7-inch mesh; 1 seine boat, $30; 1 scow, $30; 1 dory, $10; and 1 naphtha launch, the *Ro-Wa*, of 4 tons, crew 2; valued at $800.

Nineteen barrels of redfish were salted. The pack of canned salmon for the season consisted of:

Species.	Cases.	No. to the case.	Date.
Redfish	480	12	July and August.
Cohoes	1,060	7.5	Do.
Dog salmon	20	7.8	

WRANGELL NARROWS STREAM.

Emptying into Wrangell Narrows on the eastern side, opposite Finger Point and one-half mile to the northward of the astronomical station, Coast Survey chart No. 8180, is a large stream which was said to run redfish. This stream was examined by

Ensign Hepburn, and from his report it is quite probable that it is not a redfish stream and that but few salmon can surmount the obstacles. The stream is not a lake outlet, but drains the hills about 10 miles to the southeast from its mouth. Throughout its entire course, and to within one-half mile of its mouth, it follows a line of hills which lie to the northward. The opposite side is comparatively low. Three hundred yards within the mouth, at a sharp bend, is a fall to which tide water

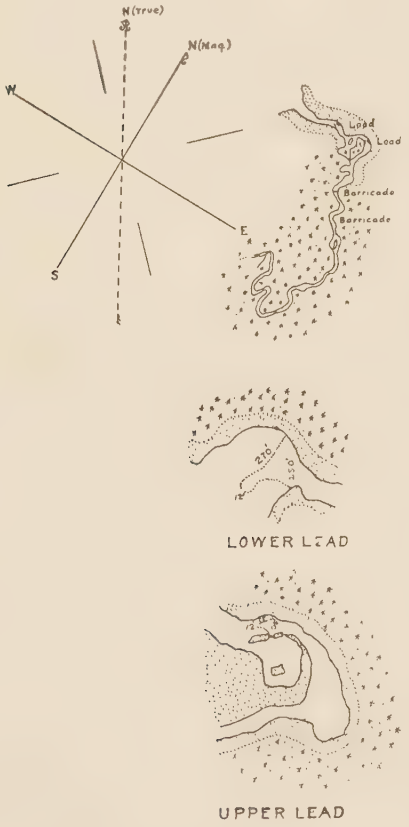
Cascade stream, east side of Wrangell Narrows, opposite Finger Point.

extends. At low water the fall is about 30 feet high, and it is only at high-water spring tides that fish can ascend. Above the falls the width is 45 feet, depth 1½ feet, and current 1½ knots. The bottom is rocky where the stream narrows, and in the wider reaches it is sandy and gravelly. The color of the water is dark, and the temperature (September 6) 2 miles from the mouth was 50° F. The banks are heavily timbered, and there is a dense undergrowth. On the left bank, beyond the stream

belt, the country seemed open. A number of dead dog salmon and cohoes were seen below the falls, and a few cohoes were noticed jumping at the falls. It was learned that dog salmon and cohoes are the only ones that try the falls at all.

SALMON BAY STREAM.

This stream was examined by Ensign Kempff and Mr. Fassett. Salmon Bay is on the northeastern end of Prince of Wales Island, about 7 miles to the eastward of Red Bay, at the junction of Clarence and Sumner straits. Salmon Bay is a narrow inlet curving in a southerly direction, about one-half mile in length, and at the head has a narrow rocky passage which, after a few hundred yards, widens, forming a tidal basin that receives the waters of a redfish stream. This stream was explored for a distance of 3½ miles to a moderate elevation, and as the lake was not reached the party returned. There was no one in the vicinity from whom any information could be obtained. It was afterwards learned that the lake is some distance in the interior. The stream is very tortuous and flows through a comparatively level country. The land around the mouth of the stream is low and grassy, tide water extending about 1½ miles within the mouth. The bottom is rocky and bowldery, with gravel patches over which fish were seen spawning. The water has the brownish tinge common to lake water in this district, and 1 mile above the mouth had a temperature of 66° F., 3 miles above the same point 58° F., September 4. The average width is about 40 feet; depth, 1 foot; current strong. No tributaries were noticed in the distance examined. About 2 miles from the mouth there is a fall or rapid, in steps about 4 feet high, which, however, does not prevent the fish from ascending. The banks are wooded, and several open spaces were noticed back of the fringe of growth bordering the stream.



Stream and leads, Salmon Bay, Prince of Wales Island.

Just beyond the head of tide water the stream during the fishing season may be barricaded. On each bank are heavy posts and on line a number of stakes driven in the stream bed, with bowlders between. It is not known exactly what this may be, but from the old web found on the banks it is believed that a net has been stretched across the stream, supported by the stakes, with the foot held in position by the bowlders.

At two points, about one-half mile within the mouth, runways or leads have been constructed by piling the rocks from either bank in V-shape, leaving the apex open. It is possible that these runways are used in connection with the fyke-shaped traps

used by the natives. On the left bank, at the outer runway, is the site of a saltery formerly operated here. Humpbacks, dog salmon, and Dolly Varden trout were the only fish seen. It is said that this stream has been much abused by barricading, and a few years ago it was believed that it was practically exhausted for commercial purposes, but redfish are still taken in considerable numbers. The stream has a probable value of 20,000 redfish and 3,000 cohoes. The only stream data obtainable are the following:

Year.	Time of run.	Species.	Number taken.
1896	July 1–30	Redfish	19,725
1896	Aug. 1–31	Cohoes	2,682
1897	July 1–15	Redfish	15,012
1898	June 28–July 20	Redfish	22,000
1899	June 20–Aug. 2	Redfish	25,401
1900	June 18–July 27	Redfish	33,290

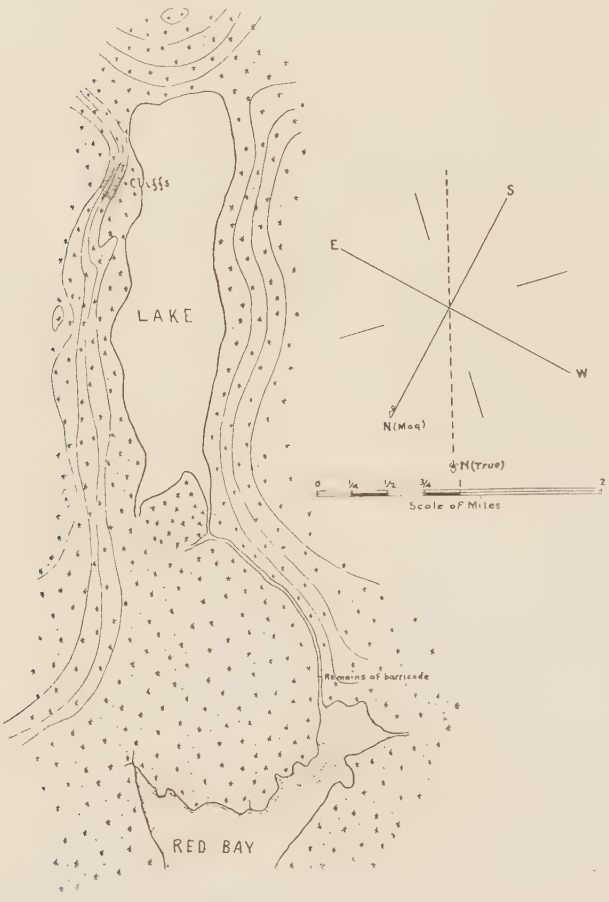
Salmon Bay saltery.—On the southern point of the entrance to Salmon Bay is a saltery formerly conducted by Mr. Tom McCauley. Several years ago the salting tanks were moved to Whale Passage, and the saltery is now used as a cooperage. The buildings, dwelling, store, etc., at the time visited were in good repair; a large number of barrels were stored in a warehouse, and quite an outfit of coopering tools was noticed, but everything was locked and no one in sight. The fish taken from the stream are sold fresh to the Wrangell cannery by Mr. McCauley, who claims the fishing right here.

RED BAY STREAM.

Red Bay is on the northern side of Prince of Wales Island and opens on Sumner Strait. (See Coast Survey chart Nos. 8200 and 8168.) The southwest extremity of the bay narrows to a pocket, which is an uncovered flat at low water, and receives at the southeastern end the waters of a redfish stream, which was examined by Lieutenant Rodman September 4. It is about 1½ miles in length, has an average width of 30 feet and depth of 12 inches, with two rocky pools about 5 feet in depth in its length; it flows in a northwesterly and northerly direction from the lake over a gravelly bottom with occasional bowlders, running with a slack current, and has no falls or heavy rapids in its course. The lake, at the point of outlet, flows in two streams, forming an island about one-half mile in diameter. The eastern bank of the main stream is generally low and flat, the western bank steep, and both timbered with the usual growth of the country. Tide water extends about 150 yards within the tree line, and the temperature of the water above this point was found to be 62° F.

The lake, which lies in a general north-and-south direction, is about 2½ miles long by one-half mile wide; it is elevated about 40 feet above sea level, and has a temperature of 61° F. at a depth of 3 feet. The eastern shore is generally steep, having near the head of the lake a gray precipitous cliff, while lying off the lower end is a small wooded island. The western shore has a more gentle slope, and all the surroundings are heavily wooded. For want of proper facilities the lake could not be examined, but at the head it appeared as though it received two feeders. The shore shelf, as far as could be seen, was gravelly.

About 200 yards from the mouth of the stream, and above tide water, forked posts were found planted on the banks, and a large number of slat racks, 8 feet by 4 feet, were stacked near by. As the current is very gentle it is probable that a heavy crossbeam is laid across the crotches, supported by stakes in the stream, and that the racks are then laid across by bedding one end in the gravel, bottom upstream, and inclining the other end against the beam. A line of bowlders across the stream probably served to ballast the lower ends of the screens, thus effectively closing it to fish on their way to the spawning-grounds. Small pieces of web and cordage were also seen in the vicinity, which may have been used in closing the stream.



Lake and stream at head of Red Bay, Prince of Wales Island.

With the means at hand two men could close the stream in about two hours. Naturally, it is free from obstruction. A few redfish, many humpbacks, and a few dog salmon were seen in the stream, confined largely to the pools, in which 500 or 600 were noticed, all in an advanced stage of ripening. The bed of the stream seemed to offer a good spawning-bed. No fish were seen in the lake, but here and in the stream large numbers of small fry, 1 inch to 3 inches long, were noticed.

It is said that this stream has been much abused by barricading, and it is difficult to obtain its real value now, as the canneries naturally do not wish to give their stream records to the public, and they are cautious in giving figures.

The following are the records as far as they are available:

Year.	Time of run.	Species.	Number.
1896	July 18–31	Redfish	16,348
1896	Aug. 1–Sept. 1	Cohoes	4,542
1897	July 7–29	Redfish	12,004
1898	July 10–Aug. 5	Redfish	24,000
1899	Unknown		
1900	July 5–Aug. 5	Redfish	11,243

The stream has a present value of not over 18,000 redfish and 5,000 cohoes for a single season.

SALMON BAY STREAM, PRINCE OF WALES ISLAND.

Riffles where humpbacks were spawning, about 2 miles from mouth.

TEBENKOF STREAM. LOG FORMING FOUNDATION OF FISH BARRIER.

The stream named "Salmon Creek" on Coast Survey chart No. 8168 of Red Bay was a mere rill at the time of our visit, and those named creeks Nos. 1, 2, 3, and 4 were not seen; they are probably small waterways during heavy rains. The stream named "Little Creek," to the westward of the redfish stream, is about as large as the latter and carries many humpbacks.

At the point marked "Fishery and Indian Village" is the site of the old saltery, formerly operated by Mr. Tom McCauley, but later moved to Whale Passage. The saltery building is in bad condition and the wharf has disappeared, except the inshore end. There are two houses near by, but no one was seen in the vicinity; the place looked abandoned. The fish were formerly used in the saltery, but are now sold by Mr. McCauley to the Wrangell cannery.

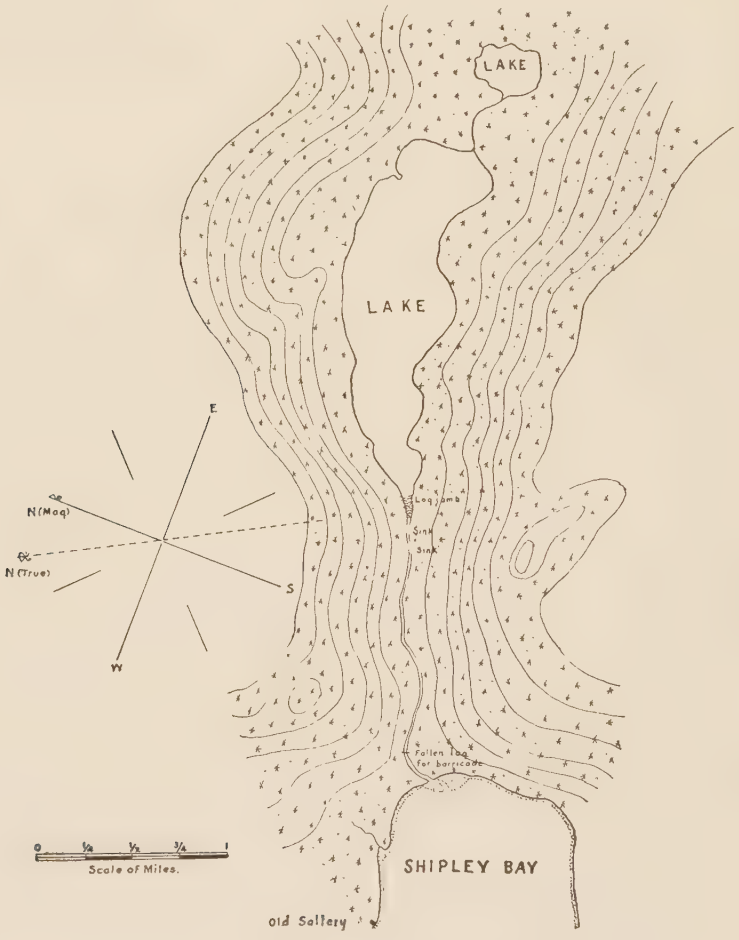
SHIPLEY BAY AND STREAM.

Shipley Bay is on the western side of Kosciusko Island, which lies close to and on the northwestern side of Prince of Wales Island, from which it is separated by Klawak Passage. It is a very deep indentation, about 6 miles long and 1½ miles wide, but much obstructed by reefs, though there is a good channel and excellent anchorage at the head of the bay. At the eastern end, toward the northern side, is a saltery formerly owned by Mr. Walter Kosmikoff, known locally as "Russian Walter," who salted salmon and at times salmon trout. Fish were sold fresh when the opportunity offered, but as it was out of the track of the cannery steamers, few were disposed of in that way, though occasionally a few were sent to Wrangell on the monthly mail boat which passes here on its run between Klawak and Wrangell.

In 1899 the saltery was purchased in the interest of the Icy Strait Packing Company and was operated, as noted, under that company. It was closed at the time of our visit, and there was no one in the vicinity.

At the extreme head of the bay and about half a mile from the saltery is the mouth of a redfish stream, which was examined by Lieutenant Rodman and Mr. Fassett, September 3. This stream, with the lake system, lies in a general east-and-west direction, the former about 1½ miles long, 20 to 25 feet wide, and 12 to 15 inches deep. It flows between steep timbered mountains, 2,000 feet high, with a strong current, over a rocky bed which has occasional gravel spots. There are many rapids in the stream, but no steep falls to prevent the fish from ascending. No stream yet visited by this party has as many natural obstructions as this one. It is choked from the lake to the mouth by fallen timbers which have come down the steep mountain side, and at two points, 50 yards and 150 yards from the lake, there have been heavy slides into the bed of the stream, the water disappearing entirely under the detritus at each point and reappearing after it has passed the obstruction. It is impossible for fish to overcome these obstacles, but it is probable that during heavy rains, which are frequent in this district, the volume of water is so great that the subsurface drains under the obstructions can not carry it all away, and there is then a flow over the top. Below these natural obstructions, where the stream again appears, the pools were filled with salmon of all species, and some trout, most of the former well matured. The stream water had the usual discoloration and a temperature of 58.5° F.

The lake is about $1\frac{3}{4}$ miles long, has an extreme width of one-half mile, and an elevation of 55 feet. The whole head of the outlet is filled with logs and dead trees; beyond this jam the shore is rocky as far as could be seen from the outlet. As there were no facilities for examining the lake, and it was impracticable to follow the shore, the party ascended a high mountain overlooking the lake and from this position made the sketch. At the extreme eastern end a second small lake was seen, connected with the main body by a fair-sized stream. Several small feeders



Lake and stream, Shipley Bay, Prince of Wales Island.

were also seen, but none of any consequence except the lake connection, near which some sandbars were noticed. The temperature of the lake near the outlet, at a depth of 3 feet, was found to be 59° F.

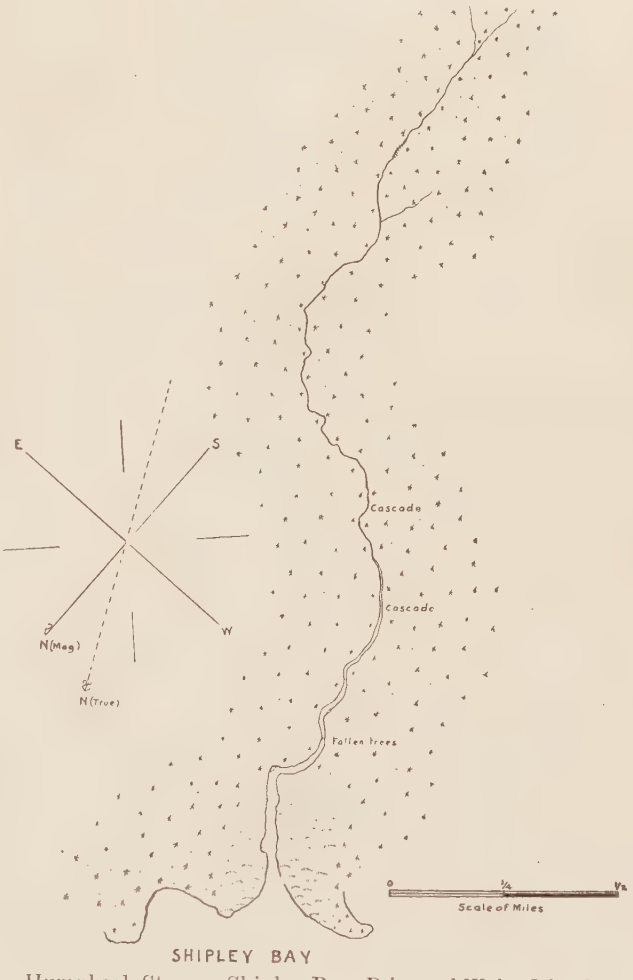
In the stream, about 50 yards above tide water, which extends but a very short distance from the mouth, some stakes and old webbing were found, and immediately above a tree had been felled across. All this may have been used for barricading the stream, but whether any obstructions have been used recently to hold the fish is unknown to this party.

On account of the natural obstructions in the stream the locality is probably not suitable for hatchery purposes. The stream data is very meager, but the following may be of some service, though it should be remembered that except for 1900 the fish taken for the saltery are not included:

In 1892 the Baranoff Packing Company took 6,762 redfish from July 9 to 20; in 1893, 5,295 redfish from July 8 to 30. In 1898 the Wrangell cannery took 5,000 redfish from July 15 to August 15. In 1900 the Icy Strait Packing Company took 12,000 redfish from June 27 to August 14. The stream has a probable value of 12,000 redfish.

SHIPLEY BAY STREAM No. 2.

On the southern side of the bay a small stream discharges into a cove formed by a long peninsula and the point next eastward. This stream was examined by Ensign Hepburn, and found to carry only humpbacks and dog salmon, though cohoes may also run later.



Humpback Stream, Shipley Bay, Prince of Wales Island.

The stream is not a lake outlet, but has its source in the mountains about 6 miles in a general southerly direction from the mouth. At a point 3 miles from the mouth, where it reaches an elevation of 170 feet, it is quite small and flows through a gently ascending and rather flat country, increasing in size toward the mouth by conjunction with small branches. Tide water extends three-eighths of a mile upstream; immediately above this point the width is about 16 feet, depth 9 inches, with a velocity of about 3 knots. The bed is generally rocky, and where it widens it is sandy and gravelly. From a point 1 mile above its mouth and for a distance of about three-fourths of a mile it runs as a continuous rapid. There are two cascades, as noted in the sketch, with the greatest sheer fall of 3 feet. The water is dark, and at the mouth and 1 mile above had a temperature of 51° F. The banks are densely wooded, but back from the stream belt the country seemed more open. At the mouth is a gravel bar, and within the banks are grassy. There are no

artificial obstructions, but throughout its entire length there is much fallen timber, which in places must offer much difficulty to the fish in ascending. Humpbacks and dog salmon were seen for a distance of about 2½ miles; all were in poor condition, and the lacerations showed the difficulties encountered in ascending. Dead dog salmon were numerous.

BAY OF PILLARS AND STREAMS.

This bay is on the west side of Kuiu Island and opens on Chatham Strait, having Point Sullivan for the northern entrance point and Point Ellis marking the southern. It is a large body of water, much obstructed by islands and reefs, and has two deep arms similarly obstructed; the one on the north will be referred to as the North Bay of Pillars, and the other as the South Bay of Pillars.

These waters have been surveyed by the Coast and Geodetic Survey, and as that office has probably written sailing directions, notes for entering will not be made here.

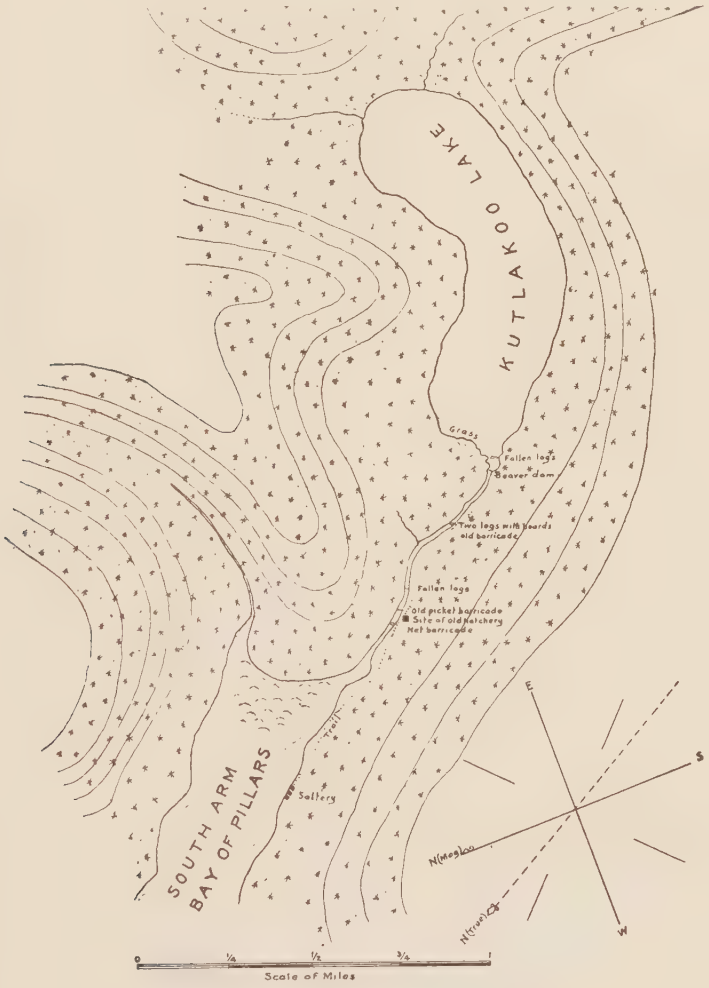
On the southern shore of the South Bay of Pillars, about 4 miles from Point Ellis, the cannery of the Astoria and Alaska Packing Company was located. This cannery was burned in 1892 (see my former report, p. 121), but the site and remaining building were purchased by Mr. Jack Mantle, who lives here during the fishing season and operates a saltery in each of the Pillar Bay arms.

The principal streams in this vicinity fished for commercial purposes are: One at the head of the South Bay of Pillars, which, when the cannery was operated, was known as the Home Stream or Point Ellis Stream (the Indian name for it is Kutlakoo); one at the head of the North Bay of Pillars, which is known as the Pillar Bay Stream; and one in the large bay to the southward (Tebenkof Bay), known as Kuiu Stream, or Alecks Stream.

POINT ELLIS STREAM, OR KUTLAKOO.

Entering the South Bay of Pillars the ship's course is close along the southern shore, quite straight, and fairly clear for a distance of 5 miles, when the bay becomes choked with islands and reefs, which straggle to the head. In the southeastern angle an arm extends to the eastward for about a mile, and receives the waters of a small humpback stream. On the northern side the bay terminates in the Narrows (Skookum Chuck), which extend in a northeastern direction about three-fourths of a mile, with a width of about 100 yards, through which the current is quite violent during the strength of the tide. These Narrows connect with an inner bay 3 miles long, in a northeast and southwest direction, by three-fourths of a mile wide, which at the eastern end sends an arm at right angles to the southward about 1 mile long by one-fourth of a mile wide, receiving at the western terminus the waters of the Point Ellis or Kutlakoo stream. This stream, examined by Lieutenant Rodman and Mr. Fassett, is a lake outlet, and from the grassy flats at its mouth to the lake is about three-fourths of a mile long, with an average width of 18 feet and a depth of 10 inches. It has a general north-and-south direction, flowing over a gravelly bottom between moderately steep banks heavily wooded. As the lake is not more than 15 or 20 feet above tide water the current is not strong, nor are there any falls or strong rapids. Tide water extends about 50 yards within the mouth.

The lake is slightly crescentic in shape, with a general northwesterly and southeasterly direction, and is about 1 mile long, with an average width of one-fourth of a mile. The shores are heavily wooded and rise rapidly to the higher mountains. The water appears deep and clear, with a brownish tinge, and as far as could be examined the bottom is gravelly around the shore shelf. At the point of discharge the lake is shallow, with a grassy bottom. There are several feeders. The largest enters the



Kutlakoo Lake and Stream, Kuiu Island.

head of the lake through a narrow valley and is nearly as large as the outlet; it forms the main spawning-ground for the redfish. A second feeder, said to be on the eastern side, was not noticed by the party.

The temperature of the stream water on August 29 was 62° F., and the lake water, at a depth of 2 feet, one-fourth of a mile from the outlet, was 61° F.

In 1892 Mr. J. C. Callbreath, the present owner of the hatchery on Etolin

Island, then part owner and manager of the Point Ellis cannery, operated a small hatchery on the left bank of this stream (Kutlakoo), about 200 yards above the mouth. It was rather primitive, the work all being conducted without shelter. The hatchery water was conveyed by a box flume from a point on the stream about 300 yards from the lake, where the remnants of a barricade built to hold the spawning fish may still be seen. About 1,000,000 eggs were fertilized and placed in the baskets, but after they commenced hatching an exceptionally high September tide destroyed the plant, and it was never rebuilt. It is said that much difficulty was experienced with fungus. At the old hatchery site stakes were found driven in the bed of the stream, between which, it is said, a net is stretched to hold the fish. A few yards above this point are the remains of a picket barricade.

Immediately below the point of discharge from the lake a beaver dam was found, built of sticks, brush, and moss, which held the waters back and allowed no fish to pass. This was partly cleaned away by the examining party, and, as the water rushed through, the stream rose very materially, and large numbers of salmon, held in the pools below, ascended rapidly.

The value of the stream, as given by the cannery the last year it was fished, is 35,000 redfish, 5,000 cohoes, and 100,000 humpbacks. The owner of the saltery states that the number for redfish is too large, but the stream will yield from 20,000 to 22,000 redfish, possibly a few more by hard fishing. The first run of redfish in this stream usually occurs from June 25 to July 1, and the second run from July 10 to August 7. The length of the season varies with the condition of the weather; if it is dry there will not be sufficient water to permit the fish to ascend, and they are held around the mouth until the water rises. These redfish run about 50 to the barrel, or 13 to 14 to the case. The cohoes in this stream are very large and run 24 to the barrel. They appear from the middle to the latter part of August; from September 10 to October 4 they run strong and continue in diminishing numbers until November. The humpbacks run from the 15th of July to the end of August, and they are present some years in large numbers until the end of September, but they are not then in good condition. The dog salmon run with the humpbacks.

It is said that a good hatchery site might be located near the large feeder at the head of the lake.

Complete stream data is not available, but the following may be of interest:

The Baranoff Packing Company took fish from the stream as follows: In 1892, 8,942 redfish, July 2 to July 25, and 2,143 cohoes, August 18 to September 8; in 1893, 2,605 redfish, July 4 to July 20; in 1894, 8,740 redfish, July 7 to July 25; in 1895, 14,572 redfish, July 4 to August 10; in 1896, 15,834 redfish, July 12 to August 28; in 1897, 11,709 redfish, July 6 to August 7.

By other fisheries: In 1898, 10,000 redfish; 1899, unknown; 1900, 16,500 redfish.

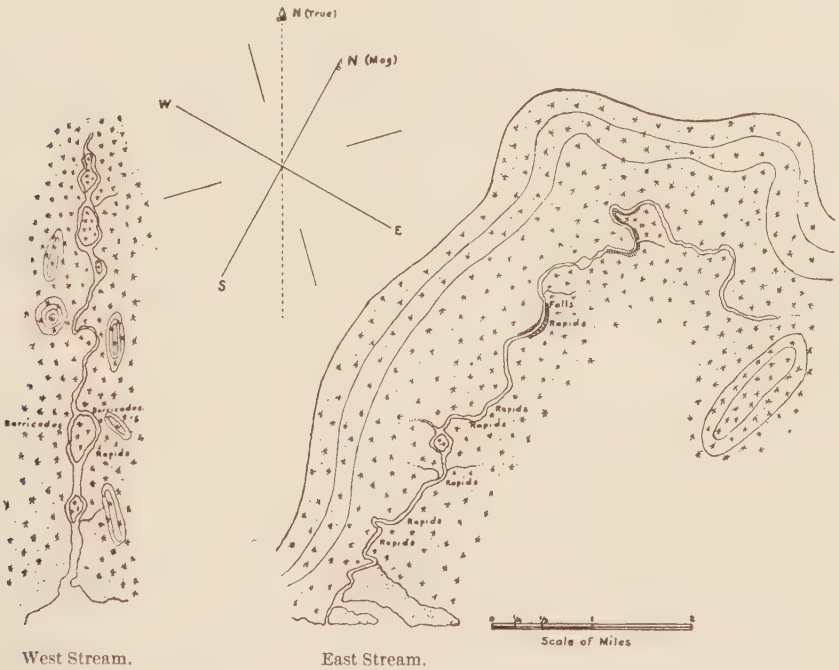
The Point Ellis stream (Kutlakoo) is the only salmon stream in the South Bay of Pillars that has any present commercial value. At the old cannery site there is a small stream, called by the Indians Quat-a-hein, or trout stream, on account of the abundance of that species, and around its mouth some years several thousand cohoes may be obtained, but it is only an occasional run.

KUTLAKOO STREAM, KUIU ISLAND.

New fence near mouth.

NORTH BAY OF PILLARS.

The North Bay of Pillars, like the South, is much obstructed by islets and reefs, and local knowledge is necessary for safe navigation. The head of the bay, however, is clear, and is 1¼ miles in length by 1 mile in width, forming a beautiful harbor with excellent anchorage in moderate depths. At the extreme northern head of the bay are the mouths of two large streams, three-fourths of a mile apart, bordered by extensive tidal flats. Neither of these streams is said to carry redfish, but all other species common to the district run here.



West Stream. East Stream.

Sketches of East and West streams, North Bay of Pillars.

PILLAR BAY STREAM.

This is the western stream at the head of the bay and is the most important, as it carries a great number of cohoes of large size. It was examined by Ensign Kempff August 29 a distance of 4½ miles, where it is elevated 40 feet above the sea.

It flows in a general south-southeast direction between steep banks, heavily wooded, over a gravelly bed. The water is clear, of a brownish tinge, as though flowing from a lake (though none was found), and at each mile from the mouth the temperature was 51° F. Tide water extends 1 mile from the mouth, at which point the stream is 9 feet wide, 12 inches deep, and runs a 3-knot current. In the length examined two tributaries enter from the eastward, one three-fourths of a mile, the other 1¾ miles, from the mouth. The stream flows around several islands in its course. The eastern channel, around an island about 2 miles from the mouth, has at the lower end a rapid about 30 yards long, and at the other end of this, and in the

western channel, are the remains of barricades. Trees have been felled across these branches and were still in position, but the split rails were washed away. A gravel ridge was noted on the upstream side, where the rails had lodged in the bed. A large number of humpbacks and dog salmon were seen spawning in the lower courses, growing less in number as the higher portion of the stream was reached. It was too early for cohoes.

This is a very large stream, flowing considerable water, and carries a heavy run of all species of salmon common to the district, except redfish, of which, it is said, there are none in the North Bay of Pillars. This is a noted locality for cohoes. Fifty thousand to 60,000 of this species, it is said, may be taken around the mouth and the head of the bay, as well as about 100,000 humpbacks. Dog salmon are also abundant. These cohoes are large and, for commercial purposes, run from September 1 to October 7, then in diminishing numbers until November. The humpbacks run from the middle of July to the end of August and the dog salmon throughout the season, but mostly during the humpback run.

There are no stream records available. Besides those salted, cannery steamers sometimes fish here for a few days, and what can be done during that time is indicated by the following record from the books of the Baranoff Packing Company: In 1892, 1,522 cohoes, September 8 to 15; in 1895, 2,836 cohoes, September 20 to 22; in 1896, 3,607 cohoes, September 15 to 19; in 1897, 957 cohoes, September 19.

PILLAR BAY STREAM, No. 2.

This stream, next east of the Pillar Bay Stream and three-fourths of a mile from it, was also examined by Ensign Kempff for a distance of 8 miles and no lake found. From the most distant point reached, which is 305 feet above sea level, the stream flows to the northwest for 3 miles and then turns in a general southerly direction for 5 miles. The water is clear and clean and flows over a rocky bottom, interspersed with patches of gravel and shoals, over which fish were spawning. There are numerous rapids, and at a point 4 miles from the mouth there is a drop of 30 feet in the main fall, besides several smaller steps. The banks are heavily wooded, precipitous, and broken into bluffs in the vicinity of the falls and at a point about 1 mile above the mouth. Tide water extends a mile from the mouth, where the stream is 30 feet wide, 18 inches deep, and runs with a strong current. The temperature, taken each mile, was 51° F. (August 30). Five small tributaries were noticed in the distance—two entering from the west and three from the east—and were examined. There were no natural or artificial obstructions below the falls. A large number of humpbacks and dog salmon were seen spawning in the lower courses of the stream, diminishing in numbers as far as the falls, but none above it.

The fishing is carried on around the head of the bay. The values given under the Pillar Bay Stream include the one just described, though it furnished but a small part of the total.

MANTLE SALTERIES.

There are two salteries operated by Mr. Jack Mantle; one on the eastern bank of the arm and near the mouth of the Point Ellis Stream, where there are 10 tanks each of 20 barrels capacity, and one on the western shore of the inner North Bay of

Pillars opposite the mouth of the Pillar Bay Stream, where 6 tanks, each of 20 barrels capacity, are operated. There is also one saltery tank at the old cannery site.

He used 1 drag seine 120 fathoms by 4 fathoms by 3-inch mesh, valued at $200; 1 scow of 100 barrels capacity, value $75; 1 35-foot seine boat, value $50, and 1 small skiff, value $25. During the fishing season he employed 6 men (native) for fishermen and 4 klootchmen for butchers. The saltery at the Point Ellis Stream is operated during the early part of the season for redfish, and when the cohoes begin to run the gear is transferred to the Pillar Bay Stream and that species is salted. Mantle commenced salting here in 1893, and has averaged about 350 barrels each year to date.

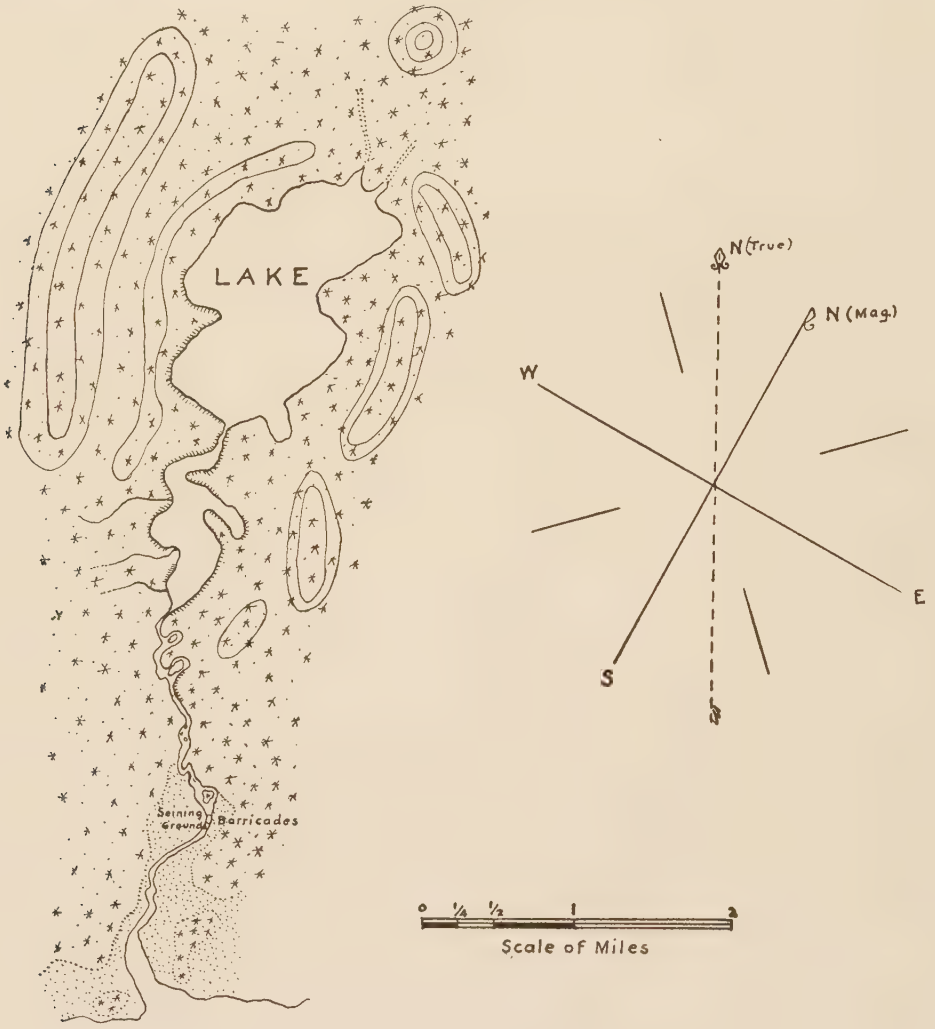
TEBENKOF BAY.

This bay is on Kuiu Island, next south of the Bay of Pillars, and opens upon Chatham Strait. It is a large sheet of water and is said to have deep channels and good anchorages, but has not yet been surveyed. Several streams carrying various species of salmon enter the bay, but only one that has a run of redfish in sufficient numbers for commercial purposes. This one is known as Kuiu Stream, or Alecks Stream. This stream was examined by Ensign Kempff and Mr. Fassett on August 31, who visited it with a party from the anchorage in Pillar Bay. It is located on the eastern side of the inner bay, about the middle of its length, and is hidden in approaching it by islands lying off the shore, but it may be recognized by a log house situated a short distance north from the mouth.

The general direction of the stream and lake system is north-northwest and south-southeast. The former is about 2½ miles in length. The stream flows over a rocky and gravelly bottom between moderately steep, well-timbered banks, and at a point midway on its course is 50 feet wide, 1 foot deep, and has a current of about 1 knot per hour. The water, though clear, has a brownish tinge and a temperature of 55° to 56° F. There are no marked rapids, and no tributaries were noticed. Tide water extends nearly a mile from the mouth, around which, at low water, extensive flats are uncovered. The stream drains two lakes. The first, a "mud" lake, is an irregular shaped body of water about 1 mile long, with an extreme width of one-half mile. It is shallow, with a muddy bottom, and has three very small and shallow feeders entering from the westward, none of which appeared to be used as spawning ground. The temperature of the water along the shores of this lake was found to be 63° F. This increased temperature above that of the stream is due probably to the shallow depth along the side where there is no circulation. At the upper end of the lake there is a narrow extension, about 250 yards long, connecting with the second lake, which is about 2 miles in length, with an extreme width of 1½ miles, and, from appearances, quite deep. The banks are steep, well timbered, and rise rapidly to the higher slopes. The beaches bordering them are gravelly with shale. The lake is at an elevation of about 50 feet above tide water, and the surface temperature of the water near the shore was 61° F. At the head it receives two large feeders, which appear to flow through converging valleys, and in these feeders are spawning beds of the redfish.

In the main stream, a short distance above tide water, posts were found which were probably used to support a net stretched across to hold the fish, a line of rocks

indicating the foot weights that had held the net close to the bed. Above this were the remains of three barricades, within a distance of 100 yards of one another, consisting of trees felled across the stream. The rails had been carried away, probably by freshets. Pieces of wire netting were found, indicating that this also had been used in its construction. A large number of humpbacks and dog salmon were seen



Aleck Lake and Stream, Tebenkof Bay, Kuiu Island.

over the gravel beds in the main stream, but no redfish, this species probably having all ascended to the feeders; the date of visit was too early for cohoes. Large numbers of dead fish were noticed.

From inquiry and observation it is believed that a good site for a hatchery might be obtained on the banks of the large feeders at the head of the lake. The redfish running in this stream are said to be small, averaging about 65 per barrel, or 15 to 16

to the case, but they run very early; in fact, the dates given are the earliest of any stream within my knowledge in southeastern Alaska. The run of redfish commences about June 1 and continues until the middle of July. The cohoes run for fishing purposes from September 1 until the early part of October, and in scattering bunches until November. The humpbacks are said to be very plentiful and are exceptionally large and fine fish. They usually run early, the time being from July 1 to August 1. The only record available is a statement that the Point Ellis cannery in one season took from around this stream 38,000 redfish, 10,000 cohoes, and 200,000 humpbacks. Mr. Jack Mantle, who has fished in this locality for many years, stated that he had seen a large run of steelheads in the stream in May.

The following notes from the records of the Baranoff Packing Company, giving their catches from this stream, may be of interest as indicating the catch of a cannery steamer visiting different localities for fish: 5,990 redfish, June 15 to July 7, 1892; 3,529 redfish, June 19 to July 27, 1893; 730 redfish, July 19 to July 21, 1895; 1,500 redfish, June 15 to July 29, 1896; 4,304 redfish, June 29 to July 7, 1897.

WRANGELL.

Glacier Packing Company, Point Highfield.—The history of this cannery with the streams fished, etc., was given in my former report, pages 103–108, and reference here will only be made to such details as were not then recorded.

There has been no change in the cannery, but the company expects to erect new buildings for the season of 1901.

In canning, the following machinery is operated: Five retorts, 2 fillers and 1 spare one, 2 toppers, 1 solderer, and 1 cutter.

The fish are hoisted by steam in buckets to the wharf, dumped into the bins, and, after cleaning, transferred direct from the draining tubs to the cutters. The daily capacity is 1,600 cases. There are no can-makers. All tins are made at the cannery by hand, except about 1,200 cases of flats, using 100-pound tin plate for bodies and 95-pound for tops, all domestic.

The Chinese contract was 42½ cents, with the usual conditions. The fishermen contracted for $125 for the run, 10 cents for king salmon, and 5 cents for redfish and cohoes, per boat of two men, and full board. The cannery purchased fish and paid 7 cents for redfish and cohoes, if the gear (web and boats) was furnished, or 8 cents if it was not furnished. Humpbacks were purchased at $10 per thousand. The cannery steamers call at the fisheries for all fish. Occasionally a steelhead is taken; there are plenty of halibut and flounders, but no shad or sturgeon since my last report.

The following are the statistics for 1900:

Hands employed: 24 white fishermen, besides purchasing from fisheries engaging 150 native fishermen, 7 white and 4 native cannery-hands, and 86 Chinese.

Fishing gear: Twelve king salmon gill nets, each 250 fathoms by 28 meshes by 8½-inch mesh; 12 redfish gill nets, each 250 fathoms by 30 meshes by 6½-inch mesh, value 65 cents per fathom; 2 drag seines, 120 fathoms by 200 meshes at bunt and 100 meshes at wings by 3-inch mesh, valued at $1.50 per fathom; 5 purse seines, 120 fathoms by 250 meshes by 3-inch mesh, value $2 per fathom.

Boats, lighters, etc.: Two lighters, $600 each; 7 seine boats, $60 each; 14 Columbia River boats, $200 each; 8 old Columbia River boats, $25 each; 5 skiffs, $25 each.

The following vessels, owned by the company, were employed:

Class and name.	Tons.	Crew.	Value.
Ship Llewellyn J. Morse	1,271	(1)	$35,000
Steamer Ella Rohlffs	36	5	15,000
Steamer Aleut	19	5	10,000

[1] Fishermen.

The following was the output in 1900:

Species.	Cases.	Number to the case.	Dates.
King salmon	1,837	3.8	May 15–July 1
Redfish	10,848	10.1	June 18–Aug. 10
Cohoes	9,401	7.4	July 10–Sept. 18
Humpbacks	36,432	15.8	July 2–Aug. 22

Thlinket Packing Company.—This company was organized at Portland, Oreg., and incorporated under the laws of that State. A sawmill at Point Gerard, on the mainland opposite Point Highfield at the junction of the Eastern Passage and the southeast stream of the Stikine Delta, was purchased, and in the spring of 1899 a cannery was erected and a small pack was made that year. The site does not afford much room on level ground, necessitating considerable crowding in the building arrangements. There is a substantial wharf with the fish-house over deep water, where the current carries away the gurry and leaves the place free from the unpleasant odors so frequently noticed around plants of this kind. The cannery plant consists of 2 steam boxes, 2 retorts, 2 hand cutters, 1 can-washer, 1 crimper, and 1 solderer. The pack is made by hand, and the plant has a daily capacity of 800 cases. The fish are pewed from boats or lighters into a chute, adjustable for different stages of the tide, which leads to a cage car, or vertical elevator, operated by steam. When this car is filled it is hoisted and its contents dumped into a second car which runs to the fish-house. All the cans, except a small percentage of flats, are made by hand at the cannery, of 100-pound domestic tin plate. The Chinese contract was 42 cents for talls made at the cannery, 38 cents for talls purchased, and 42 cents for flats purchased, with the usual conditions. The fishermen's contract was transportation and board, bonus of $80 each for beach work, 10 cents for king salmon, 5 cents for redfish and cohoes, and 1 cent for humpbacks, per boat. The fishing bosses had allowances which brought their monthly wages to $70 or $75, and the others averaged $50 and $55 per month. Indian labor was used, but it is not looked upon with favor on account of being unreliable.

Four traps were built this year at an expense of $5,500, located as follows: One in Dry Strait; 1 in the lower part of the southeast stream of the Stikine; 1 about 300 yards west from the cannery, and 1 in Zimovia Strait, about 10 miles below Wrangell. The first three were complete failures, although rebuilt several times; the fourth was

fairly successful and about paid the expenses connected with all. The following are its dimensions: Lead, 150 fathoms, heart double, 15 fathoms across, and pot 36 feet square, in 70 feet of water at high water. A short channel lead, or wing, extended from the corner of the heart. Webbing all tarred; 4-inch mesh for the leads, 3-inch mesh for the rest.

Sketch-plan of Thlinket Packing Co.'s salmon trap, located on Zimovia Strait.

The transportation was by regular steamer lines running from Puget Sound to Alaska.

The following are the statistics for 1900:

Hands employed: 35 white and 30 native fishermen, 9 white and 7 native cannery-hands, 49 Chinese.

Fishing gear: In addition to the traps referred to, 13 king-salmon gill nets, each 200 fathoms by 22 meshes, 9¼-inch mesh; 12 redfish gill nets, each 200 fathoms by 24 meshes, 6¼-inch mesh; value, 65 cents per fathom; 4 drag seines 100 fathoms long by 178 meshes, 3-inch mesh, value $1.50 per fathom; 1 purse seine 185 fathoms by 220 meshes, 3-inch mesh, value $600; 1 purse seine 100 fathoms by 160 meshes, 3-inch mesh, value $400.

Boats, lighters, etc.: One house scow, $400; 1 fish scow, $100; 10 Columbia River boats, $200 each; 6 gill-net skiffs, $60 each; 6 seine boats, $60 each; 2 whitehalls, $85 each; 3 skiffs, $20 each.

Cannery tenders: Launch *Perhaps*, 6 tons; crew, 2; value, $1,500; owned. Steamer *Baranoff*, 10 tons; crew, 5; value, $5,000; chartered.

The following was the output in 1900:

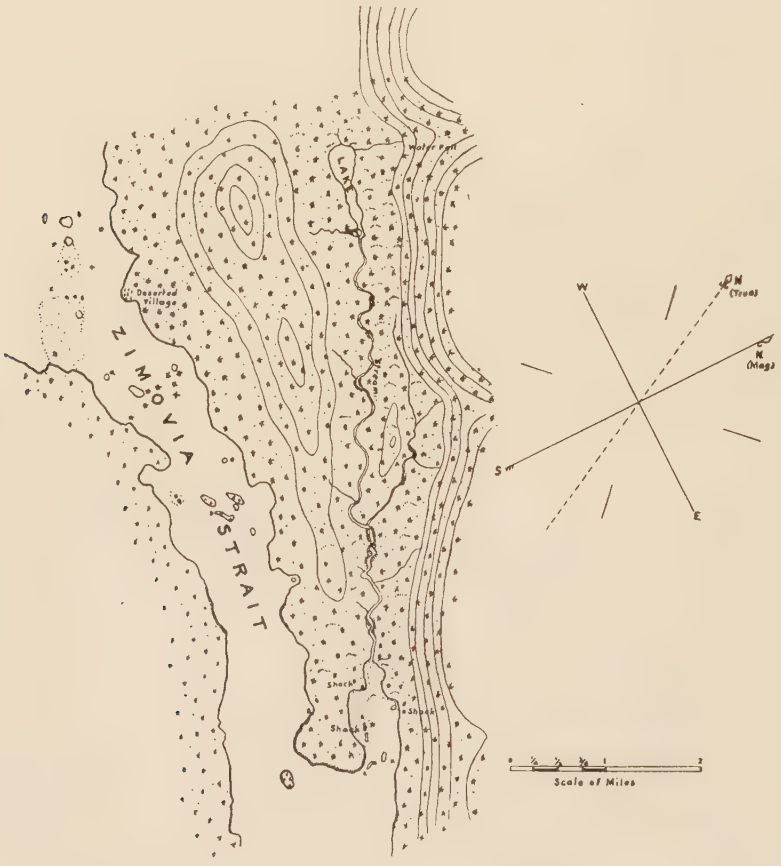
Species.	Cases.	Number to the case.	Dates.
King salmon:			
Red	[1] 1,375	3	May 14–June 28
White	[2] 674		
Redfish	[1] 505	11	June 28–Aug. 16
	[2] 3,460		
Cohoes	[2] 2,349	7.5	Aug. 2–Sept. 21
Humpbacks	[2] 15,540	18	July 12–Aug. 31
Dog salmon	[2] 1,737	6.5	Aug. 1–Sept. 15

[1] Flats. [2] Talls.

The streams fished by this cannery are the following: Southeast Pass Stikine River, Anan Bay, Seward Passage, Thoms Place, Kunk Creek, Rocky Bay, Steamer Bay, Eagle Creek, Ratz Harbor, Red Bay.

THOMS STREAM (AW-AW), ZIMOVIA STRAIT.

Near the southern end of Zimovia Strait, on the eastern side, 4 miles northwest from Found Island, is a bight with several islets and rocks at the entrance. At the head of this bight is a redfish stream, referred to in my former report, page 107, as Old Village, but better known as Thoms Stream, fished by the Wrangell and Gerard Point canneries. It was examined September 13 by Lieutenant Rodman.



Thoms Stream and Lake, Wrangell Island.

This stream and lake drain a low, flat country, lying between mountain systems, reaching an elevation on the east of 2,000 to 2,500 feet, and on the west 500 to 1,000 feet. In its windings the stream is fully 6 miles in length from mouth to source, and, in a straight line, about 4½ miles in a general WNW. direction. Tide water extends through extensive flats around its mouth, uncovered at low water and about 200 yards within the tree line, where it is 55 feet wide and from 12 to 18 inches deep. The banks generally are low, but in places there are narrow canyons where they rise abruptly. The borders are wooded with the usual growth, but considerable areas of boggy, moss-covered flats were noticed. The bottom is gravelly, with patches of rock and bowlders, but there are large areas well adapted for spawning-beds;

about 1½ miles below the lake the stream runs over a series of rapids; the highest fall of any of the steps is not over 2 feet. There are no falls or serious obstacles to impede the ascent of fish, the stream is usually clear, and there were no evidences of barricades. The water is brownish in color, with a temperature of 54° F. There are a number of small tributaries, one of some size about 2½ miles from the mouth; this is about 2 miles long and has its source in the mountains to the eastward. The altitude of the main stream at the mouth of the tributary is 155 feet and of the lake 295 feet. The latter is small, pear-shaped, and about 1 mile long, with a greatest width of not much more than one-fourth mile. The lower end is narrow, apparently shallow, and has many pond lilies. The shores are low and, though wooded, there is considerable open country, particularly on the eastern side, where there are large areas of grassy, boggy flats.

At the lower end on the western side there is a feeder, and one at the upper end, in which the sound of falls was heard. It is possible that there are other feeders or lake connections, as the volume of discharge is large. From the surrounding conditions it is believed that a good hatchery site might be found here.

The only stream records available are the following:

Species.	1897.		1898.		1900.	
	No.	Date.	No.	Date.	No.	Date.
Redfish	17,138	June 28–Aug. 6	10,000	June 28–Aug. 1	24,661	June 26–Aug. 1.
Cohoes	1,992	Aug. 16–31	5,000	Aug. 10–Sept. 1	7,651	Aug. 5–Sept 12.
Humpbacks	42,169	July 12–Aug. 18			74,000	Aug. 5–18.

Under average conditions the stream has a value of about 20,000 redfish and 5,000 cohoes.

MEYERS STREAM, CLEVELAND PENINSULA.

Lemesurier Point, the northwestern end of Cleveland Peninsula, forms, with a string of islands to the westward of that point, a narrow bay, at the head of which is the mouth of a stream fished by Mr. Meyers. This stream carries a few redfish, and was partially examined by Lieutenant Rodman on September 14.

The stream is very small, and when examined there was so little water running in it that at low water humpbacks could not enter. At the mouth it was about 8 feet wide, with an inch of water over a riffle for a distance of 150 yards. A mile above the mouth it was a mountain brook, flowing between rocks and bowlders, with here and there a shallow pool. Tide water extends about 150 yards upstream. At a distance of 1 mile the elevation is 70 feet, and the temperature of water was 51° F. The stream bottom is rocky, with gravel patches, and the banks are well wooded. Many of the pools were filled with spawning humpbacks in an advanced stage of decay, and many dead fish were seen along the banks. In places the bottom was covered with spawn.

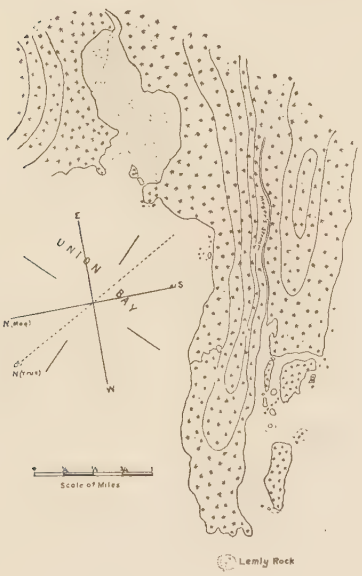
The stream is said to have a lake source, but the examination was not continued to the lake. Later it was learned that the stream is usually very low and that fish can not ascend until after the fall rains raise the water.

Formerly the fish from Meyers stream were sold to the Loring cannery. None were purchased by Loring in 1900. The following is the only record available:

Species.	1896.		1897.		1898.		1899.	
	No.	Date.	No.	Date.	No.	Date.	No.	Date.
Redfish	4,651	July 16–Aug. 7	4,700	July 20–Aug. 20	6,838	July 13–Aug. 30	3,211	Aug. 8–Sept. 8
Cohoes	1,408	Sept. 1–Sept. 14	2,250	Sept. 1–Sept. 20	256	Aug. 20–Aug. 30	.....	.....
Humpbacks	.....	.....	9,874	July 26–Aug. 26	11,499	July 20–Aug. 30	8,760	Aug. 8–Sept. 8

It is probable that the cohoes were obtained from the large stream at the head of Union Bay, which is said to carry no redfish, but some cohoes and humpbacks.

It is believed that, through the rapacity and greed of fishermen, the salmon fisheries of the northwestern coast of the United States are rapidly declining. Other fields are now being sought in order that these also may pay tribute, and soon they will enter the exterminating process.



Meyers Stream, Cleveland Peninsula.

Great Northern Fish Company.—This is one of a number of small canneries and salteries, capitalized from the Puget Sound and Columbia River districts, which sprang into existence this year in southeastern Alaska. This company, not incorporated, hails from Seattle, and fitted out for an extensive salting expedition in a rather novel way. It was arranged to follow the fish; to salt from a barge, from shacks on shore, from salteries, if they could be rented, or from schooners; to occupy a station where fish were plentiful, and when they became slack to pack up and locate where they were abundant; to salt everything of all species, from the best to the worst, from those fresh out of the water to others not so fresh; to salt direct into barrels and boxes, and to carry the product to Seattle and there resalt and assort. The first grades were intended for the best markets, the second for bars and free lunches, and the third for districts where one salt fish is not known from another. Old saltery men shook their heads and said salmon could not be salted that way. It was tried, however, but with what ultimate success could not be learned. It was said this company expected to salt 20,000 to 30,000 barrels of salmon during the season.

Union Bay was one station selected to carry on this work. At the eastern point of entrance to this bay a long tongue of land, bordered on the western side by a few islands, makes to the southward, forming a narrow, shallow cove about a mile in length. Inside the entrance point a bight makes into the tongue for a distance of about 200 yards, and at the head is a saltery of the above company. At the time of our visit the place was closed and no one was in sight.

The outfit here consisted of a rough board building 20 by 40 feet, evidently the bunk and mess house; a rude wharf floored over with saplings cut from the adjoining forests, and a raft of logs lashed together and floored over with saplings. There was no equipment of any kind.

It was afterwards learned that the outfit arrived at Union Bay May 27, and left with all the gear on September 1 for Karta Bay, one white crew having been sent there in advance August 1. The old Baronovich saltery, at the latter place, was rented by the month and operated by this company.

During our visit at Karta Bay they were salting dog salmon for the Japanese market, for which they said they had an order to furnish 300,000. These salmon were simply gutted, the viscera and gills removed, and, without being otherwise cleaned, they were salted in kenches, and, after shrinking, resalted in boxes for shipment.

On September 23 the Baronovich saltery was closed, the equipment, pack, and attendants placed on barges or transferred to the steamer *Dirigo*, and the outfit transported to Cholmondley Sound, where the Miller saltery had been rented.

The following outfit was used by the Great Northern Fish Company: Launch *Griffin*, crew 3, value $3,000, chartered; 1 cargo lighter, $1,000; 1 scow, $150; 2 scows, $60 each; 5 seine boats, $80 each; 3 skiffs, $35 each; 3 purse seines, 220 fathoms by 16 fathoms, 2¼-inch mesh, value $750 each; 3 drag seines, each 120 fathoms by 8 fathoms, 3-inch mesh, $1.75 per fathom; 2 gill nets, each 50 fathoms by 50 meshes, 5½-inch mesh, 65 cents per fathom.

There were employed 30 white salters and beach men, 16 white fishermen, 15 white and 4 Indian casuals; about one-half of these were hired in Alaska. From the middle of September the white men began to leave and return to Puget Sound, and more Indians were then employed. Steady hands received in pay and allowance an amount equal to about $60 per month, whites and natives alike, but the casuals, who are sailboat tramps, were paid on whatever terms could be arranged; sometimes it was board and keep until the arrival of the *Pardner*, and again it was passage to the Sound with the next shipment. The boxes used for shipping dry-salted dog salmon to the Sound held from 750 to 800 pounds. Those used to ship to Japan held 400 pounds, or from 48 to 50 cured fish.

This company also chartered the schooner *Volunteer*, 12 tons, and sent her to Redfish Bay for salting purposes. The record to September 23 was 41,024 redfish salted. Arrangements were also made to take the output of the Point Barrie saltery, formerly operated by Cyrus Orr, but now by a Russian called "Zip" Moon, and 300 barrels of redfish and dog salmon were expected from this source. The company also claimed to have made arrangements at Boca de Quadra to dry-salt dog salmon and to put up black-cod as Pacific-coast mackerel, but inquiry at that point failed to elicit any information confirming this. There are probably few black-cod in those waters, except strays.

It was also proposed to carry on extensive herring salting at Point Barrie during the fall and winter, and the barkentine *Blakeley* was said to be en route (September 23) to Karta Bay, to be sent later with an outfit to Port Bucarelli for 2,500 barrels of salt herring.

It has since been learned that this company failed. Diligent inquiry was made as to the results of its operations, and the following is the approximate output for the season: 5,000 barrels salted salmon of all kinds, principally humpbacks; 30,000 dog salmon, dry-salted, for the Japanese market.

RICE'S SALTERY, KARTA BAY.

Rice's saltery, Karta Bay.—Owing to the failure of the salmon run in Puget Sound, Mr. J. E. Rice, of Whatcom, Wash., came to Karta Bay, August 20, with a small outfit and commenced salting salmon on the southeastern shore of the inner bight, in a shack rented from the Baronovich family. The pack consisted largely of dog salmon, dry-salted and shipped in boxes, though other species were not neglected and were salted direct in barrels. No salting tanks were used.

The equipment consisted of 2 seine boats, $50 each; 1 fish scow, rented from the Loring cannery; 3 dories, $30 each; 1 seine, 175 fathoms by 6½ fathoms, 3-inch mesh, valued at $1.50 per fathom. All labor was hired in the vicinity; 15 to 20 men were employed during the season, and were paid $3 per day without board or lodging. Fish were also purchased from the Indians at the following rates: Redfish and cohoes, 10 cents each; humpbacks, $6 per thousand; dog salmon, $15 per thousand.

The following was the output for the season: Seventy-five barrels redfish, 25 half-barrels redfish, 75 barrels cohoes, 50 half-barrels cohoes, 575 boxes dry-salt dog salmon, averaging 55 fish to the box, or 31,625 cured fish, weighing 241,400 pounds.

The barrels used were full size, machine-made, with galvanized hoops, and cost, in Puget Sound, $1.50 each. In salting without tanks the fresh fish are salted in the barrels, the fish forming their own pickle; after four or five days' shrinking the barrels are filled with fish to the top and weighted, and after complete shrinkage they are resalted, the barrels headed and placed chime up; an auger hole is then bored in the upper chime and the barrel kept filled with pickle.

Mr. Rice prepares his dog salmon by butchering in the usual manner, except that the head is left on. After thorough cleansing in salt water they are salted down with coarse salt, flesh up, in piles called "kenches," about 4 feet square and 4 feet high. In from four to six days, depending upon the weather, the fish having shrunk sufficiently, the excess of salt is shaken off, the inside is sprinkled with clean Liverpool salt, folded back in the shape of the fish, and boxed; a sprinkling of salt is placed on the outside to keep the fish from sticking together. It is said that fish prepared in this manner keep a long period.

Mr. Rice also purchased all halibut of 40 pounds weight and over at a uniform rate of 50 cents each; these were flitched, dry-salted in kenches, and shipped to the Sound, where they were washed and smoked for market.

KARTA BAY STREAM.

This stream, described on pages 88 to 90 in my former report, has been very much overfished during the past few years; it is said there were as many as 30 seines at work in the vicinity of the mouth of the stream during the height of the last run.

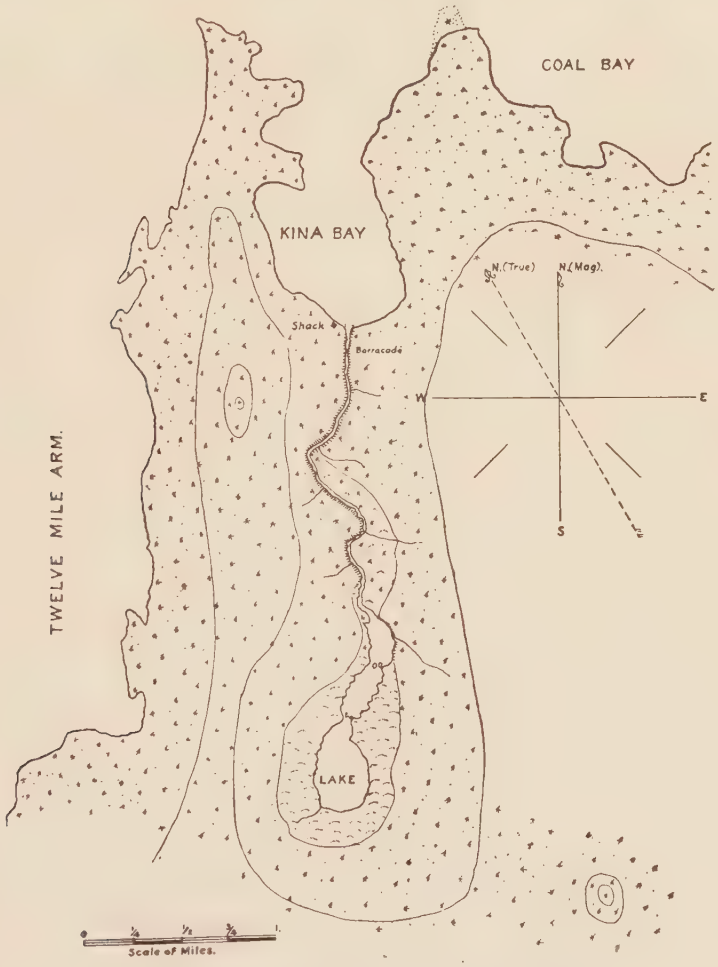
The following contains only the catch of three canneries for 1898, 1899, and 1900; that of the salteries and smaller fisheries is unknown.

Species.	1898.		1899.		1900.	
	No.	Date.	No.	Date.	No.	Date.
Redfish	106,876	June 16–Aug. 11	55,730	June 18–Aug. 15	63,305	June 19–Aug. 20
Cohoes	14,855	Aug. 25–Sept. 15	4,000	Aug. 14–Sept. 12	6,224	Aug. 30–Sept. 20
Humpbacks	25,680	Aug. 1–Aug. 11	114,743	July 22–Aug. 14	185,676	July 18–Aug. 20

These numbers are probably too small by 20 per cent. An estimate made by a canneryman, who has a very good knowledge of this stream, gives the catch of redfish from this stream in 1898, 120,000; in 1899, 85,000; in 1900, 100,000.

KINA STREAM, KASAAN BAY.

Between Coal Bay and Twelvemile Arm there is a large unnamed bight, which extends nearly 2 miles into the southern shore, and which receives at its head the waters of a small stream called Kina, referred to in my former report, page 90.



Lake and stream, Kina Bay, Prince of Wales Island.

This stream was examined, on September 22, by Ensign Miller who found that it had its source in a lake. It is about 1½ miles long, with a width of from 10 to 40 feet, and depth from 12 to 18 inches, with pools 4 feet in depth. It flows through a heavily wooded, rolling country, between rocky banks from 20 to 50 feet high, and over a bowldery and gravelly bed showing here and there exposed ledges. The

water has the usual brownish tinge common to lake water in this district, and had a temperature of 53.5° F., while the small tributaries had a temperature of 49° to 50° F. There are no falls, but in the lower end, where the stream narrows, there is a series of rapids which, however, do not prevent fish from ascending. Tide water extends about 100 yards within the mouth, and a short distance beyond is a barricade of the usual log and sapling form, having, at the time visited, some of the poles missing. There are numerous fallen trees across the stream. The upper half widens toward the lake and has a sluggish current. The lake is 135 feet above sea level and consists of three ponds, connected by small straits. The whole system is about 1 mile in length with a greatest width of less than one-quarter mile. It is surrounded by many flats and is quite shallow, with pond lilies and grasses growing over the bed. The temperature of the lake water was 55° F. There are several small feeders entering the lake and stream, as indicated on the sketch. The stream and lake system lies in a general north and south direction.

Numerous humpbacks and dog salmon were seen around the mouth. This stream was formerly fished by Mr. Myers, who sold the catch to Loring. It has not a large output, as the following records, the only ones available, will show:

Species.	1896.		1897.		1898.	
	No.	Dates.	No.	Dates.	No.	Dates.
Redfish	2,018	July 29–Aug. 23	1,500	July 19–Aug. 16	774	July 29–Aug. 16
Cohoes			470	Aug. 8–Sept. 4	2,291	Aug. 31–Sept. 5
Humpbacks			15,000	July 19–Aug. 16	5,754	July 29–Aug. 16

WARD COVE, TONGASS NARROWS.

About 5 miles to the westward of Ketchikan a small bay makes in on the northern shore of Tongass Narrows, known as Ward Cove, and referred to in my previous report, page 65. A mining boom has been been attempted here, and on the western side of the cove a very small village has been built, consisting of a steamer wharf, store, a few dwellings, and a post-office, called Revilla. A sawmill has been built at the head of the bay on the western point of entrance to the redfish stream. Opposite, on the eastern head, there was formerly a saltery, purchased some years ago by the Alaska Packers Association and since dismantled. All that remains now is the shack of an old Indian, who salts a few barrels of salmon during the season.

Ward Cove Stream empties into the head of the cove, and is the outlet to a chain of lakes. It was examined by Ensign Hepburn September 15. It flows in a fairly straight course in a southerly direction over rocky bottom, with a rapid current throughout its length, between high bluff banks well wooded. Tide water extends a short distance within the mouth. The stream water is fairly clear, and had a temperature of 56° F. It is about three-fourths of a mile long, and 100 yards below the lake has a width of 20 feet, a depth of 9 inches, and a 3-knot current.

The first lake is oblong, one-half mile long by one-fourth mile wide, and is elevated 70 feet above tide water. On the east and west the mountains impinge on the lake. On the southeastern side there is a narrow, swampy valley which has several small streams draining through it. Toward the north the country is generally low, with small hills. It is generally well timbered, and along the shore in many places

there is a dense growth of grass and berry bushes. The temperature of the lake water was 55° F. About the middle of the northern shore there is a feeder, which is said to be a lake connection. Near the entrance point it has a width of 60 feet, depth of 4 inches, and a 2-knot current, flowing over a coarse gravel bottom. About 1 mile from the lake and just beyond a large island the feeder has a fall of 7 feet sheer, and one-half mile above this there is a heavy cascade extending a length of

Lake and stream, Ward Cove, Revillagigedo Island.

100 feet and having sheer falls of 2 to 3 feet. There is also a cascade in the branch that flows around the western side of the island, but the branch on the eastern side is clear. The temperature of the water in the feeder, 2 miles from the lake, was 50° F. The feeder was followed for a distance of 2½ miles, until it was apparent that no fish could go farther, but no other lake was seen, though it is reported by the natives that there are two more beyond. No fish were seen above the falls.

A few humpbacks were seen spawning along the shore of the lake, though the principal spawning-beds are in the first half mile of the feeder, where humpbacks were seen in great numbers, as well as many of another species, probably redfish. A large number of dead fish were seen along the borders of the lake and feeder.

Judging from the surroundings, a good hatchery site might be located near the mouth of the feeder. In the main stream outlet no sign of artificial barricades was noted. A number of fallen trees lie in the stream, but form no serious obstacle.

The following is the only record available:

Species.	1897.		1898.		1899.		1900.	
	No.	Date.	No.	Date.	No.	Date.	No.	Date.
Redfish	1,500	July 24–Aug. 23	1,535	July 21–Aug. 25	1,000	.....	873	July 13–Aug. 23
Cohoes	600	July 24–Aug. 13	743	July 19–Aug. 25	1,000	.....	1,179	July 13–Sept. 7
Humpbacks	11,000	.....do	34,935	July 21–Aug. 30	15,000	.....	52,511	Aug. 3–Sept. 7

The above represents the catch of one cannery calling occasionally and making a seine haul. Several other canneries, at intervals, also fish the place.

It is probable that the stream has a value of 5,000 redfish, 1,000 cohoes, and 50,000 humpbacks.

KETCHIKAN.

The saltery formerly operated here by Clark and Martin has been closed and the property absorbed by a local company, who have extended the wharf for the accommodation of steamers and made additions to the saltery for warehouse purposes.

Ketchikan cannery of the Fidalgo Island Canning Company.—This company engaged in packing salmon at Anacortes, Wash., and built a cannery in the spring of 1900 on the northern shore of Tongass Narrows, about one-half mile east from the old Clark and Martin saltery (see former report, page 65). The buildings are substantial, well located, clean, and the cannery arranged to make a hand pack. Fish are conveyed from the boats by an endless-chain conveyor, adjustable for the tides, to the fish-house built over the water; the cleaned fish are conveyed to the cutters on push carts. The tables of the butchers have sprays over them.

The following machinery is used in the canning process: Four steam boxes, 3 retorts, 1 washer, 1 topper, 2 crimpers, 2 solderers, and 1 cutter, all adjustable to the different sizes packed. The filling tables accommodate 60 workers; daily capacity of cannery, 1,200 cases. The cans are all made at the cannery by hand, of 100-pound domestic tin plate. It is probable that fillers will be introduced and the cannery enlarged in 1901, though a hand pack is preferred.

The Chinese contract was 45 cents for 1-pound talls and flats, and 43 cents for one-half pound flats per case of 48 cans. Filling was paid for separately at the rate of 6 cents per case of 48 tins. Fishermen received $40 per month, and collectively, $10 per thousand for redfish and cohoes, $2 per thousand for humpbacks, with full board and transportation; the boss fisherman had $75 per month. Fish were purchased from Indians and others at the following rates: Redfish and cohoes, 7 cents each; dog salmon, $15 per thousand; humpbacks, $7 per thousand; the cannery providing boats and gear. Transportation is by regular line of freight steamers.

The cannery obtained fish from Quadra, George Inlet, Ward Cove, Carroll Inlet, Thorne Arm, Kah-Shakes, Duke Island, Smeaton Bay, Hassler Harbor, Point Alava, Annette Point, Dalls Head, Bostwick Inlet, and Fish Creek.

The following are the statistics for 1900:

Hands employed: 34 white, 38 natives, and 3 Japanese fishermen; 6 white and 50 native cannery-hands, and 50 Chinese.

Fishing gear: Eight purse seines, each 175 fathoms by 10 to 12 fathoms, 3-inch mesh, $3 per fathom; 2 drag seines, each 160 fathoms by 6 fathoms, 3½-inch mesh, $1.75 per fathom.

Boats, lighters, etc.: Three lighters, $75 each; 2 lighters, $225 each; 2 scows, $20 each; 12 seine boats, $70 each; 8 dories and skiffs, $30 each. Steamer *Delta*, 59 tons, crew 6, value $6,000, chartered.

No salting was done at this cannery. The following was the pack of canned salmon in 1900:

Species.	No. of cases.	No. to the case.	Date.
Redfish	[1] 437 [2] 1,573 [3] 4,389	11.5	July 10–Aug. 31
Cohoes	[1] 470 [2] 112 [3] 250	10	July 13–Sept. 8
Humpbacks	[1] 8,425 [2] 6,175 [3] 5,135	19.3	July 13–Sept. 8
Dog salmon	[1] 304	8.5	Aug. 24–Sept. 8

[1] 1-pound talls. [2] 1-pound flats. [3] One-half pound flats, 96 per case.

NAHA STREAM AND LAKES.

This stream was referred to in my former report, pages 94–97, and described as far as the falls in the stream connecting Lake No. 1 and Lake No. 2. On September 1, Lieutenant Rodman and Ensign Kempff, with an Indian guide, examined lakes Nos. 2, 3, and 4 as far as any fish can ascend, and from their report the following is condensed, reference being made to the sketch accompanying this report:

Stream connecting Lakes Nos. 1 and 2.—From the falls above Lake No. 1 the stream maintains its volume and flows over a rocky and gravelly bottom; it rises gently to Lake No. 2. Just below this lake is a series of small cascades, none of which is over 2 feet in height or forms any obstruction to the ascent of salmon. One or two small tributaries enter the stream on the northern side, but they are unimportant. The stream throughout its length was full of humpbacks. The distance between Lakes No. 1 and No. 2 by the stream bed is about 2½ miles, but by trail along the northern side the distance from the falls to Lake No. 2 is materially less.

Lake No. 2.—Altitude, 50 feet; temperature of lake and stream, 55° F. This lake is gourd-shaped, with a rather rounding basin about half a mile in diameter, making its length, with the long narrow neck on entering, about three-fourths of a mile. The shores, except the western side, are rocky and gravelly, and the lake generally has a very clear appearance. But few pond lilies and little grass were noticed anywhere.

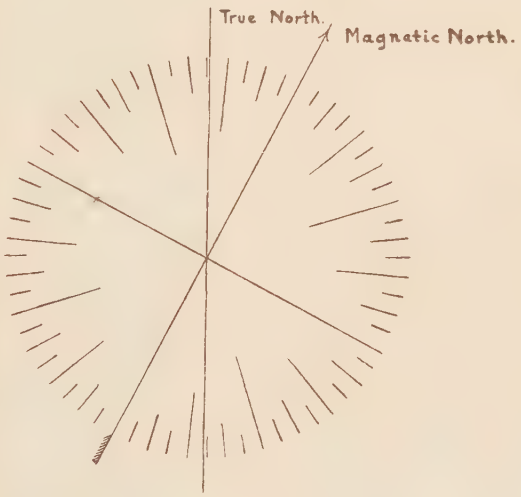
On the western side there is a feeder about 30 feet wide by 8 inches deep, which, according to the guide (who owns and hunts the land bordering the lake system), is the outlet to a lake lying about 1½ miles to the northward. About 1 mile from the mouth it has a high fall, which prevents fish from ascending to the lake; as far as the fall, however, there is good spawning-ground.

Stream connecting Lakes No. 2 and No. 3.—This stream is about 2 miles long, 80 feet wide, and 14 inches deep, with a fall of 103 feet in its length. It was only examined at the lake ends, but it can have no serious obstructions, as redfish enter Lake No. 3. The mouth of the stream, and for one-fourth mile above, was full of humpbacks, but they do not enter Lake No. 3. The temperature of the water in the stream was 55° F. At the head of the stream, at its source in Lake No. 3, there is a small island, partly in the lake, around which the waters from both lake and stream flow.

Lake No. 3.—Altitude, 153 feet; temperature of water, 56° F. The length of this lake is about 2½ miles, with a width ranging from one-fourth to one-half mile. The northern shore is comparatively straight, very steep, and rocky; the other shores are low and flat, with open glades, permitting easy travel; the southern side is marked by several deep indentations. At the extreme eastern head is a feeder which was not examined.

Stream connecting Lakes Nos. 3 and 4.—This stream enters Lake No. 3 at the eastern end, near its head, where it is about 60 feet wide, 8 inches deep, with a temperature of 56° F. It is about a mile long following the stream bed, though the lakes are only about one-half a mile apart in a straight line. It has a fall of 167 feet in its length, part of which is over sheer falls, making it impossible for salmon of any kind to enter Lake No. 4. The first fall is about one-fourth mile above Lake No. 3, beyond which no fish were seen, and while it is possible that it can be passed, it is not probable that they can pass over the series of cascades at the head of the stream where it leaves Lake No. 4. Here the fall is at least 100 feet in one-fourth mile, and the water rushes along with great velocity, without any eddies or resting places. Redfish were seen as far as the first fall.

Lake No. 4.—Altitude, 320 feet; temperature of water, 56° F. The length of this lake is about 3½ miles, with an average width of one-fourth mile, expanding toward the head. The banks are steep and the shore lines, as far as examined, are rocky. It is said that there are two more lakes in this system connected with Lake No. 4, but as no salmon can enter the latter, it was not deemed necessary for our purposes to continue the examination any further. In Lake No. 4 many cutthroat trout were seen, but no salmon or signs of them. The water throughout the lake system was unusually low. In Lake No. 4, judging from the marks along the shore, it appeared to be 2½ feet below a mean level. There were no barricades in any of the streams. The whole system has all the natural features for excellent spawning-grounds; the streams are clear, free from obstruction, there is much sand and gravel, little or no mud, and plenty of water, with moderate current. The color of the water becomes lighter as the upper lakes are reached. At Lake No. 1 it is tinged a deep brown, and at Lake No. 4 it is much lighter in color.



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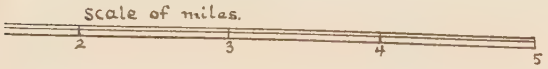
Approved:

Joseph F. Moser.

Commander, U. S. Navy, Com'd'g.

BEHM CANAL
HA STREAM
AND
KE SYSTEM.

Sketch
by
ugh Rodman and Ens. C.S. Kempff, U.S.N.,
Under the direction of
ommander Jeff'n F. Moser, U.S.N.,
ommanding U.S.F.C.S. Albatross.



The head of Lake No. 3 would afford an excellent site for a hatchery. There is an abundance of water, which could be conveyed by gravity, and plenty of spawning fish. Another site could probably be found at the mouth of the feeder in Lake No. 2, but it is probable that spawning fish might not be so easily obtained.

In addition to the record of the stream given in my former report, page 96, the following may be added:

Species.	1898.		1899.		1900.	
	No.	Dates.	No.	Dates.	No.	Dates.
Redfish	18,377	July 20–Aug. 2	13,176		15,224	July 1–Sept. 21
Cohoes	5,000	Aug. 15–Sept. 15	1,000		2,000	July 15–Sept. 1
Humpbacks	150,000	July 15–Aug. 15	189,650		150,000	July 31–Sept. 1

LORING.

Alaska Salmon Packing and Fur Company.—The cannery of this company was described in my former report, pp. 92 to 94, but additional information and the statistics for 1900 will be given here. The following machinery is used in canning: Six retorts, 2 fillers, 2 toppers, 2 solderers, and 1 cutter. The daily capacity is 1,800 cases. There are no can-makers; all tins are made at the cannery by hand, using 100-pound plate for bodies and 95-pound plate for tops, of which 16 per cent is imported. There is an inclined railway from the fish-house, Y-shaped at the tide-water end, which admits a steamer into the Y at any stage of the tide. Fish are discharged on either side into cars, which are hauled to the fish-house by cable operated by steam. A new cannery is to take the place of the old one for the season of 1901.

The Chinese contract was 42½ cents, with the usual conditions; fishermen received $45 per month and board, from the time of signing to the day on which they were paid off. In purchasing fish the following prices were paid: 5½ to 7 cents for redfish, 7 cents for cohoes, and $6 to $7.50 per thousand for humpbacks. All the fishing gear and boats were supplied by the cannery.

The following are the statistics for 1900:

Hands employed: 100 white fishermen, besides 150 natives employed at fisheries from whom fish were purchased; 20 white and 40 native cannery-hands; 120 Chinese.

Fishing gear: Twenty-four purse seines, each 150 to 200 fathoms by 7 to 12 fathoms, 3-inch mesh, valued at $2.50 per fathom; 16 drag seines, each 150 to 200 fathoms by 4 to 6 fathoms, 3-inch mesh, valued at $1.50 per fathom.

Boats, lighters, etc.: Two cargo lighters, $150 each; 42 seine boats, $50 each; 20 fish lighters, $75 each; 1 whitehall, $50; 12 skiffs, $20 each.

The vessels used were as follows:

Class and name.	Tons.	Crew.	Value.	Remarks.
Steamer Arctic	21	5	$4,000	Owned.
Steamer Novelty	33	5	12,000	Do.
Ship Sintram	1,495	(1)	50,000	Chartered.

[1] Crew fishermen.

The following was the pack in 1900:

Species.	Cases.	No. to the case.	Dates.
Redfish	16,219	12	June 17–Aug. 29
Cohoes	3,825	9	Aug. 29–Sept. 18
Humpbacks	47,114	19	July 17–Sept. 6

YES BAY.

Boston Fishing and Trading Company.—In my former report, pp. 97 to 100, this cannery is described, together with the home stream and lake system, which were examined at that time. Reference will here be made only to the changes and additional data, together with the statistics for the season.

The barricade has been removed from the stream and it is now clear of this obstruction. The trap formerly referred to is still used at the mouth of the stream. It has a lead from the eastern shore of 300 feet, a channel lead of 100 feet, and heart 100 feet; on the side are two pots, one 30 feet by 30 feet, the other 28 feet by 28 feet. It extends a long distance across the banks at the mouth of the stream and with a short net extension the entire stream can be closed.

Excepting the king salmon, all the species of salmon are represented in this stream; steelheads are rarely taken, shad and sturgeon have never been seen, Dolly Varden trout are abundant, and at times there are numbers of halibut and flounders. In the spring tomcod are abundant.

Practically all the redfish packed at this cannery come from the home stream. The cohoes come from the home stream, Burroughs Bay, and scattering; humpbacks principally from the home stream and Short Bay, though some are received from the Hot Springs, Gedney Pass, Spacious Bay, Stewart River, and adjoining inlets. Dog salmon are taken scatteringly from all the above places, and the king salmon all come from Burroughs Bay. This cannery has not fished Checats since 1897.

The following is the record of the home stream since the date of my last report:

Species.	1898.		1899.		1900.	
	No.	Dates.	No.	Dates.	No.	Dates.
Redfish	44,271	July 12–Sept. 3	69,000	July 14–Sept. 13	80,000	July 14–Sept. 17
Cohoes	6,413	Aug. 11–Aug. 29	6,300	Aug. 7–Sept. 13	7,700	Aug. 11–Sept. 17
Humpbacks	45,000	July 15–Aug. 30	75,000	July 12–Sept. 6	60,000	July 15–Sept. 14
Dog salmon			500	July 14–Sept. 13	2,250	July 21–Sept. 17

The following machinery is used in the canning process: Four iron retorts, 1 steam box, 1 filler, 1 crimper, 1 solderer, and 1 cutter. The tops are put on by hand. All tins are made at the cannery by hand, of 90-pound domestic plate. Fish are pewed from boats and lighters to the fish-house, and after cleaning are passed directly from the draining tubs to the cutter. The daily capacity of the cannery is 800 cases. The Chinese contract was 38½ cents, with the usual conditions. Fishermen received $40 per month, from time of arrival to day of departure, with full board and transportation. The klootchmen (native women) were paid for cannery work $1.25 per day, and the bucks from $1.50 to $2.50 per day, the butchers receiving the highest rates. Fish were also purchased for which the following rates were paid: Redfish

5 cents each, cohoes 6 cents each, humpbacks 75 cents per hundred, dog salmon, in good condition, 2½ cents each. The cannery finds all gear.

The following are the statistics for 1900:

Hands employed: Fifteen white and 15 native fishermen, 5 white and 15 native cannery-hands, 61 Chinese.

Fishing gear: One trap, previously described, value $1,000; 1 purse seine, 230 fathoms by 20 fathoms, value $2.50 per fathom; 3 drag seines, 175 fathoms, 150 fathoms, and 120 fathoms long by 10, 8, and 6 fathoms deep, all 3-inch mesh, value $1.50 per fathom; 2 gill nets, each 100 fathoms by 32 meshes, 10½-inch mesh; 2 gill nets, each 100 fathoms by 35 meshes, 6½-inch mesh, value 65 cents per fathom.

Boats, lighters, etc.: Five lighters, $50 each; 4 seine boats, $50 each; 6 skiffs, $25 each. Steamer *Rosie*, 8 tons, crew 2, value $2,500, owned. Transportation by regular line of freight steamers.

The following was the pack in 1900:

Species.	Cases.	No. to the case	Dates.
King salmon	713	*2.5	June 25–July 10
Redfish	9,825	8.5	July 13–Sept. 7
Cohoes	2,306	7.5	Aug. 20–Sept. 27
Humpbacks	20,051	15	July 18–Sept. 18
Dog salmon	728	6	July 10–Sept. 27

BOCA DE QUADRA.

These waters and the cannery of the Quadra Packing Company were described in my former report, pages 62 to 64, and only the additional information which has been obtained will be referred to here.

Salteries.—The Clark & Martin saltery at the mouth of Quadra redfish stream has tumbled down through decay and is practically abandoned. Near this site a saltery was operated in 1899 by Mr. Hilton, from Bellingham Bay, who dry-salted about 4,000 dog salmon. In 1900 the saltery was operated by Mr. Z. Doty, from Whatcom, who also salted a few dog salmon. Neither of these men had any gear; they simply bought the "slop overs," as they are called, dog salmon or "chums," from the cannery seines.

In 1899 a Mr. D. Blaauw, from Tacoma, built a saltery on Grouse Island and operated it the same way as mentioned under the other salteries. He dry-salted about 14,000 dog salmon (chums), and shipped them to the Sound. In 1900 the saltery was closed.

Quadra Stream, described in my former report, is one of the best redfish streams in Southeast Alaska, and is noted for the large fish which it carries. It has attracted the attention of the canneries operated in the vicinity, and so vigorous is the fishing carried on that it is believed very few fish ever reach the spawning-grounds. In 1899 it was fished by the Loring cannery with 8 purse seines, the Quadra cannery with 8 purse seines, and Metlakahtla cannery with 2 purse seines, or a total of 18 purse seines. In 1900 it was fished by the Loring cannery with 8 purse seines, the Quadra cannery with 8 purse seines, the Ketchikan cannery with 8 purse seines, the Metlakahtla cannery with 2 purse seines, a fishery from Port Gravina with 2 purse seines, and 2 independent gangs with 1 purse seine each, or a total of 30 purse seines.

When it is considered that the stream is only about 50 or 60 feet in width at the mouth, and the inlet, Mink Arm, is less than one-half of a mile in width, it may be fancied that a fish has very little chance to escape the 30 purse seines that are constantly sweeping these waters, which are deep and bold and permit seining into the mouth of the stream. If there is no law regulating such fishing, there is one permitting the closing of such streams, and unless properly regulated this stream should be closed until the rapacity and greed of the fishermen have subsided. In my former report the value of Quadra Stream was given as 50,000 redfish, and it is believed that this number can be taken under average conditions with safety to the stream.

So far as data have been obtained from the different canneries fishing this stream, the following is the record, which, however, does not include the catch of independent fisheries and salteries:

Year.	Species.	Number.	Date.
1895	Redfish	97,000	
1896	do	137,000	July 13–Aug. 31
1897	do	65,000	
1898	do	98,138	July 12–Aug. 29
	Cohoes	5,664	Aug. 18–Sept. 4
	Humpbacks	100,000	July 15–Aug. 15
1899	Redfish	166,232	July 16–Aug. 28
	Cohoes	4,522	Aug. 20–Aug. 28
	Humpbacks	301,000	July 17–Aug. 10
1900	Redfish	174,614	July 12–Aug. 31
	Humpbacks	223,000	July 15–Aug. 12

Quadra Packing Company.—The cannery of this company was described in my former report. From it has sprung the Icy Strait Packing Company, the salteries at Taku, Bartlett Bay, and Shipley Bay, the new cannery now building at Bartlett Bay, and it is said another cannery is to be built in Sitkoh Bay next spring (1901).

The machinery employed in the canning process consists of 4 steam boxes, 2 retorts, 1 capper, 2 crimpers, 1 washer, and 1 cutter. The cans are filled by hand, for which purpose there are filling tables for 40 operators. The daily capacity is 800 cases. The tins are all made at the cannery by hand of 100-pound plate, 50 per cent of which is imported.

The Chinese contract was 45 cents for hand-filled cans, with the usual conditions. The fishermen received transportation, board, $35 per month, and, collectively, 1 cent each for redfish and cohoes, $2 per thousand for humpbacks, and $4 per thousand for dog salmon.

Fish were purchased at the following rates: Redfish and cohoes, 7 to 10 cents; humpbacks, $10 to $12 per thousand; dog salmon, $15 per thousand. The higher price was paid when no gear was furnished. Native fillers received 7 cents per case. Transportation was by regular line of steamers.

There are very few steelheads in these waters; only two were brought to the cannery this season. Neither shad nor sturgeon have ever been taken; a few halibut are found around the cannery during the packing season.

The following are the statistics for 1900:

Hands employed: 24 white and 40 native fishermen, 5 white and 25 native cannery-hands, 43 Chinese.

There were used 8 purse seines, average 180 fathoms by 15 fathoms, 3-inch mesh, valued at $3 per fathom; 1 drag seine, 115 fathoms by 8 fathoms, 3-inch mesh, valued at $2 per fathom; 1 house scow, $75; 8 seine boats, $100 each; 9 skiffs, $30 each. Steam-tender service was furnished by the Icy Strait Packing Company.

The following was the pack in 1900:

Species.	Cases.	No. to the case.	Dates.
Redfish	6,000	10.7	July 14–Aug. 25
Cohoes	600	7.5	Aug. 25–Sept. 20
Humpbacks	6,000	20	July 17–Aug. 31
Dog salmon	1,000	7	Do.

METLAKAHTLA.

Metlakahtla Industrial Company.—There has been but little change in this cannery since the date of my last report, in which the conditions were described on pages 66 and 67. The money advanced by the friends of Mr. Duncan for the construction of the cannery has been paid in full with interest, and it is now free of debt, the profits being expended for the welfare of the community and for the improvement of the village.

The cannery has a good location on a large wharf, which permits the largest steamers alongside at all stages of the tide. It is well lighted, commodious, and thoroughly clean. The buildings are large enough for a pack of 40,000 cases, and the plant has a daily capacity of 700 cases. All the work, from first to last, is done by Indians—men, women, and children. No whites are employed in the cannery, fisheries, or steamers, and, as Mr. Duncan wishes to give employment to as many natives as possible, the pack is made entirely by hand.

The only machinery used is 1 cutter, 1 crimper, and 1 solderer. On the wharf is an elevator for transferring fish from the boats to the fish-house. The first cooking is done in boiling water, for which 5 boxes are used, and for the second cooking there are 3 retorts. All the tins are made at the cannery, of 100-pound domestic plate. All the packing cases are made in the community sawmill. The lacquering is done by Indian girls, who roll the cans by hand on pads covered with lacquer.

The children receive 50 cents to $1 per day, and adults from $1 to $3 per day.

In purchasing fish the following prices are paid: Redfish, 7 cents; cohoes, 8 cents; dog salmon, 2½ cents; humpbacks, 1 cent.

The following are the statistics for 1900:

Hands employed: 24 native fishermen, besides 38 from whom fish were purchased; 174 native cannery-hands.

Fishing gear: Eight purse seines, average 158 fathoms by 8½ fathoms, 3-inch mesh; 4 drag seines, average 163 fathoms by 6 fathoms, 3-inch mesh; 5 gill nets, average 172 fathoms by 4 fathoms, 5½-inch mesh.

Boats, lighters, etc.: Two lighters, $100 each; 7 seine boats, $50 each; 6 sailboats, $100 each; 10 dories, $25 each.

Transportation by regular line of steamers.

The cannery steamers employed were: *Herald*, 17 tons, crew 5, value $9,000, owned; *Marie G. Haaven*, 12 tons, crew 5, value $5,000, owned.

The following was the pack in 1900:

Species.	Cases.	No. to the case.	Dates.
Redfish	6,930	13.7	June 20–Sept. 5
Cohoes	610	7.9	July 27–Sept. 12
Humpbacks	9,690	20	July 18–Sept. 4
Dog salmon	330	7	

No salting has ever been done here. The streams fished for the cannery are the Home Stream, Tamgas, Duke Island, Quadra, Karta Bay, Kithraum, Peter Johnson, Nowiskay, Old Johnson, Kegan, and Kagahine.

KLAWAK.

North Pacific Trading and Packing Company.—This cannery and its surroundings were described in my former report, pages 109 to 115, and only such additional information as seems pertinent to bring the records up to date will be referred to here.

The cannery, together with all the buildings, sawmill, store, etc., was burnt on September 18, 1899. In the spring of 1900 the same company built a new cannery about a mile south from the old site and on the opposite side of the arm, where it is more accessible to vessels. It is considerably larger than the old plant, and modern machinery has been installed. In the canning process the following machinery is used: Four retorts, 1 filler, 1 topper, 1 solderer, and 1 cutter. This should give the cannery a daily capacity of 800 cases. The fish are butchered on a float and conveyed to the cutter by a conveyor on the endless-chain principle.

The Klawak cannery, representing the earliest in Alaska, was, from 1878 to 1896, operated by Indian labor. These people demanded more and more each year until the expense of the pack became greater than it would have been had Chinese labor been employed. The result was that the cannery slowly introduced the latter. In 1896 there were employed in the cannery 62 natives and 2 Chinese, and in 1900 13 natives and 46 Chinese.

The following are the statistics for 1900:

Hands employed: 55 native fishermen, 10 white and 13 native cannery-hands, and 46 Chinese.

Fishing gear: Nine purse seines, each 175 fathoms by 240 meshes, 3-inch mesh, valued at $300 each.

Boats, etc.: One scow, $100; 11 seine boats, $80 each; 5 skiffs, $25 each.

Transportation was by special sail, chartered.

The cannery steamers were the *Klawack*, 10 tons, crew 4, value $5,000, owned; *Cora*, launch, 5 tons, crew 2, value $1,500, owned.

The following was the pack in 1900:

Species.	Cases.	No. to the case.	Dates.
Redfish	8,228	14.2	June 17–Aug. 25
Cohoes	3,973	8	July 21–Sept. 25
Humpbacks	15,551	17	July 17–Aug. 27

The cannery obtained its fish principally from the Home Stream, Sar-Kar, Warm Chuck, and Hetta.

In order to continue the data for the Klawak Stream, given in my former report, the following record may be added:

Species.	1898.		1899.		1900.	
	No.	Dates.	No.	Dates.	No.	Dates.
Redfish	36,881	June 20–Aug. 8	75,000	June 16–Aug. 20	31,000	June 17–Aug. 24
Cohoes	11,664	Sept. 7–Sept. 29	5,000	Aug. 15–Sept. 18	500	Aug. 14–Sept. 24
Humpbacks	65,000	.....	53,000	.....	200,000	July 16–Aug. 27

The *Albatross* did not visit the cannery this season, and the above information, together with the following, was obtained by interviews with the superintendent.

Klawak Hatchery.—This hatchery, described in former report, was moved in 1898 from the head of the main stream to the mouth of Three-mile Stream, a lake feeder on the northern side. The new hatchery house is 60 feet by 18 feet, and contains twelve troughs, 16 feet by 14 feet, arranged in pairs, with a passage around each pair. There are 6 baskets to a trough, each basket holding 50,000 eggs, giving the hatchery a capacity of 3,600,000 eggs. The hatchery water is supplied by a flume from the head of the feeder. About 50 yards within the mouth of the feeder a fence with a trap holds the spawners, from which they are seined as wanted.

The only hatchery data available is the following: In 1898, July 23 to August 26, 736 females were stripped, obtaining 2,586,000 eggs, 2,150,000 of which were hatched. This would give 3,513 eggs to the fish and the loss about 17 per cent.

The highest and lowest monthly temperatures of the water are as follows: June, 48°, 44°; July, 48°, 46°; August, 54°, 50°; September, 52°, 44°; October, 46°, 39°; November, 44°, 32°; December, 40°, 35°. At a temperature of 50° F. the fish are hatched in about 70 days; the longest period of incubation thus far has been 120 days; eye-spots appear in 27 days, and the egg-sac is absorbed in 42 days.

The young fish are siphoned from the troughs into buckets as soon as hatched, and planted in a shallow part of the lake. It is said here that the young fish go to sea the spring of the second year after the parent fish has entered the stream. The milt of 2.5 to 3 males is used for impregnating the eggs of every full female. This year (1900) several thousand young fish were marked by cutting off the fleshy fin.

The following is the output for three years: 2,586,000 eggs and 2,150,000 fry in 1898; 3,600,000 eggs and 3,000,000 fry in 1899; 3,600,000 eggs, about 1,000,000 fry in 1900 (nearly all eggs were lost by a hard freeze).

Information was received that, owing to the very severe weather in Alaska this year, all the eggs in the hatchery were frozen.

HUNTER BAY.

Pacific Steam Whaling Company.—Time did not permit a visit to this cannery during the season of 1900. The cannery and the district were visited in 1897 and fully described in my former report, pages 68 to 73.

The following statistics and additional information were obtained by personal interviews with members of the company and the cannery superintendent.

The cannery machinery consists of 2 steam boxes, 5 retorts, 2 fillers, 2 solderers, and 1 cutter, giving it a daily capacity of 1,600 cases. Topping is done by hand. Fish are pewed to the fish-house, and thence passed by hand direct from the draining tubs to the cutters. There are no can-makers; all tins are made by hand at the cannery, of 100-pound plate, 66 per cent of which is domestic.

The Chinese contract was 42½ cents per case. The white fishermen received transportation and board and were paid 5 cents for redfish and the same for cohoes. The cannery also purchased fish and paid 6 cents for redfish, 6 cents for cohoes, and one-half cent for humpbacks. Native wages were 25 cents per hour for adult males, and $1 to $1.50 per day for klootchmen.

The following are the statistics for 1900:

Hands employed: 21 whites, and employed and purchased fish from 121 natives: 10 white cannery-hands and 90 Chinese.

Fishing gear: Twenty-two seines, square hung, for drag seines or pursing by hand; they average 195 fathoms by 5 fathoms, 3-inch mesh; value, $1.50 per fathom; 2 lighters, $100 each; 2 fish-scows, $50 each; 22 seine boats, $50 each; 3 skiffs, $25 each, and 1 pile-driver, $800.

The following steamers were owned and operated by the cannery:

Class and name.	Tons.	Crew.	Value.
Steamer Alice	19	5	$12,000
Steamer Golden Gate	59	9	25,000
Gasoline launch Alphonse XIII	5	2	3,000

The transportation is by calling vessels of the Pacific Steam Whaling Co

The following was the pack in 1900:

Species.	No. of cases.	No. to the case.	Date.
Redfish	7,828	12.8	June 18–Aug. 10
Cohoes	4,070	9	July 31–Sept. 10
Humpbacks	31,709	18.6	July 17–Aug. 28

The following localities are fished by this cannery: Karta Bay, Hetta Inlet, Nichols Bay, Hunter Bay, Moira Sound, Klakas Inlet, Nutqua Inlet, Sukkwan Inlet, Hessa Inlet, Peter Johnson Stream, Eeke Inlet, Cholmondeley Sound, Skookum Chuck, Klawak, and Copper Mountain Bay.

The Pacific Steam Whaling Company, in connection with the cannery, operate a hatchery which is situated on Hetta Lake.

HETTA STREAM.

This stream was fully described in my former report, pages 73 to 75. As it is one of the large redfish streams of southeastern Alaska, and as many wild statements have been made in regard to the catch from it, the following data, added to that previously given, makes a complete record from 1886 to 1900, both years inclusive.

It may be added that this record is the entire catch from Hetta Stream by the canneries at Hunter Bay and Klawak and the saltery at Hetta, but does not include any fish taken for local use or the small salteries, if any were taken by the latter.

Species.	1898.		1899.		1900.	
	No.	Date.	No.	Date.	No.	Date.
Redfish	179,109	June 10–Aug. 3	250,834	June 15–Sept. 5	138,733	June 17–Aug. 23
Cohoes	290		539			
Humpbacks	25,000	July 25–Aug. 25	229,556	June 27–Aug. 23	58,216	

The hard fishing of this stream commenced in 1896, and unless it has received an impulse from some other source, as from Mr. Callbreath's hatchery, there is no doubt that the locality is overfished.

M'HENRY INLET.

On the eastern side of Etolin Island is a large bay (represented on Coast Survey chart No. 8200 without any soundings), having numerous islands and reefs, and a rather uninviting appearance; it is known as McHenry Inlet. At the head of the inlet are two bights or coves, which are very foul and at low water expose many ledges and extensive flats. The cove at the east receives at its head a small stream, known as Falls Creek, and, a little to the southward, a second stream called Trout Creek. The head of the western cove receives the waters of a small stream which is a lake outlet, and on this lake is the hatchery of Mr. John C. Callbreath.

There is a deep-water channel through McHenry Inlet which leads to a beautiful, spacious, landlocked harbor, near the head of the inlet, for which the following directions may be of service:

Directions for entering McHenry Inlet.—On account of the small scale of the chart No. 8200, and the absence of names, the approach is rather difficult to describe. At the entrance to the inlet (see chart) is a string of islets and rocks making off to the northwestward from Avon Island. North from the rock named Quartz Rock is a large wooded island, having an extensive reef projecting to the westward. Northward from this is a small wooded island, having a rock off its southeastern end, and north of this is another small islet having a rock, marked on the chart, off its southern end; the latter islet is the guide to the channel and will here be called Entrance Islet. It is small, rocky, and heavily wooded; the central trees projecting highest give it a conical appearance, and, as it is quite symmetrical, it presents about the same shape from all sides. In standing for McHenry Inlet bring Entrance Islet to bear ENE., and stand for it, shaping course on near approach to pass it close to, about 75 yards, leaving it to the southward. Nearly ahead, and in the center of the inlet, will now be seen Dot Islet, a low rocky islet lying close to the water, with a few low trees and bushes growing over it, and south of it, near the southern shore, will be seen a bare rock. The channel lies between Dot Islet and the rock. After passing Entrance Islet, the course should bend to the southward so that in heading midway between Dot Islet and the bare rock, Entrance Islet will be directly astern.

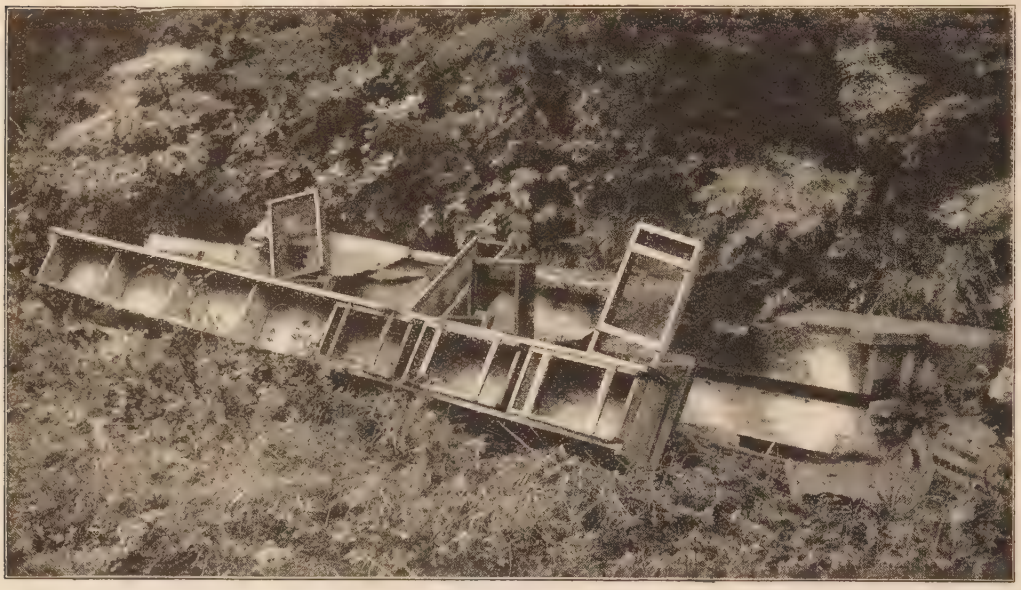
Having passed Dot Islet, keep to the southward of mid-channel for 1 mile, then haul to mid-channel and anchor about a mile below the head of the inlet, favoring

the eastern shore. Do not attempt to enter the bight or coves at the head, or approach them too closely, as they are very foul. The anchorage is in 20 fathoms, soft bottom, about one-half mile below the point of the tongue separating the two coves, and toward the eastern side.

CALLBREATH HATCHERY.

Mr. John C. Callbreath has been a resident of Alaska for many years; he was the manager of the Point Ellis cannery until it was destroyed by fire in 1892, and has lately been engaged in the transportation business on the Stikine River and in trading, making his home at Wrangell. He is a representative citizen, enterprising, and devoted to salmon culture.

In 1892, in connection with the Point Ellis cannery, he started the hatchery referred to under that stream heading. Having seen the rise of the salmon industry,



Ruins of trough and baskets, Callbreath's old hatchery.

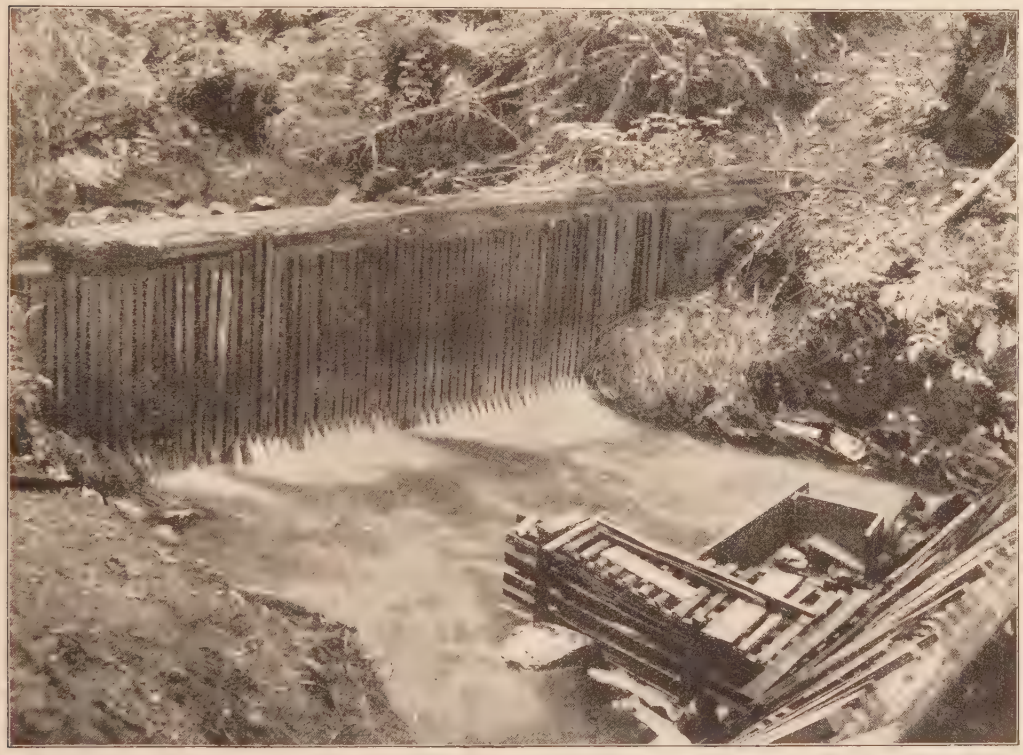
and knowing, as all must know who are familiar with the question, that the abusive and excessive fishing and total disregard of the law by the fisheries must slowly but surely exterminate the salmon for commercial purposes, he determined to take a salmon stream that under normal conditions carried a few thousand redfish, and by artificial propagation increase the production to hundreds of thousands. He hoped that, if successful, a law would be framed making all the increase his own property.

The hatchery is a private enterprise, unconnected with any cannery or fishery, and based upon the widely prevailing belief that the salmon return to the parent stream in four years after they are hatched. As this time has passed, however, without any apparent return, Mr. Callbreath has extended his period to ten years.

In establishing the hatchery a stream was sought satisfying the conditions imposed, and one was found at the head of McHenry Inlet. It is small, about one-

half mile in length, and flows over a rocky and bowldery bed between heavily wooded shelving banks. At its head is a small lake 42 feet above tide water, slightly L-shaped, about three-fourths mile long by one-fourth wide, and bordered by low wooded banks. The stream was never known to supply more than from 3,000 to 5,000 redfish, a number too small to attract the attention of the commercial fisheries. In fact, it was known as a "cultus chuck" or worthless stream.

After making satisfactory arrangements with the Indians claiming the stream, a hatchery was built in 1892 on the right bank about 200 yards from the mouth, and suitable dams were thrown across the stream to impound the fish. The hatchery water was taken from the stream, conveying it by a flume from a point near the



Trap pen and barrier in lower course of stream, Callbreath's Hatchery, McHenry Inlet.

lake, where a dam was built. After operating the hatchery during the latter part of the season in 1892 and turning out about 600,000 fry, it was seen that the breeding fish could not be impounded properly in the stream, many dying, probably from exhaustion in attempting to pass the barrier; it was also found that the stream water used in the hatchery was unsuitable, not only on account of the wide range in temperature, but the organic matter it contained smothered the eggs and caused fungus. An excellent site having been found on the lake in the vicinity of the streams forming the natural spawning-beds, with a spring giving an abundant supply of pure water of very equable temperature, the hatchery was moved in the spring of 1893 to its present site. It was operated that year and every year until 1900, when the pro-

jector decided that his means would not permit him to continue the work unless some return was made.

From its first inception it was determined that, in order to obtain the best results, only the most desirable species should be admitted to the lake, and that all enemies must be removed and excluded. In order to carry this into effect dams were built across the stream with racks below them, as shown in the sketch, at a point about 100 yards from salt water, where an islet divides the stream into two parts. The dam and fence on the western side of the islet allow nothing to pass. The fence on the eastern side has a trap opening, admitting fish to the foot of the dam. Here the redfish and cohoes are lifted by dip nets to the pool above, from which point they can ascend quickly to the lake. Nothing can enter the lake which is not passed over the dam by hand. The humpbacks, dog salmon, Dolly Varden trout, and all enemies, are carefully excluded, and the lake is therefore free of undesirable and predatory species. The lake has been carefully fished, and all enemies to the fry, such as cut-throats and other trout, sticklebacks, bullheads, sculpins, etc., have been removed, so that it is comparatively clear of enemies.

The hatchery is located on the northern side of the lake, about three-eighths mile from the head of the outlet, and midway between a series of 11 springs and feeders, the extreme distance being less than one-fourth mile from the main building. The hatching-house stands on the border of the lake, partly over a small feeder, and back of it is a substantial and comfortable log dwelling, 20 feet by 36 feet. Strung along the lake are two houses for the hatchery hands, each 12 feet by 16 feet, a smoke-house for smoking the stripped fish, and a tool-house. The original cost of the plant, and all expenses connected with it to date (September, 1900), amount to $16,000.

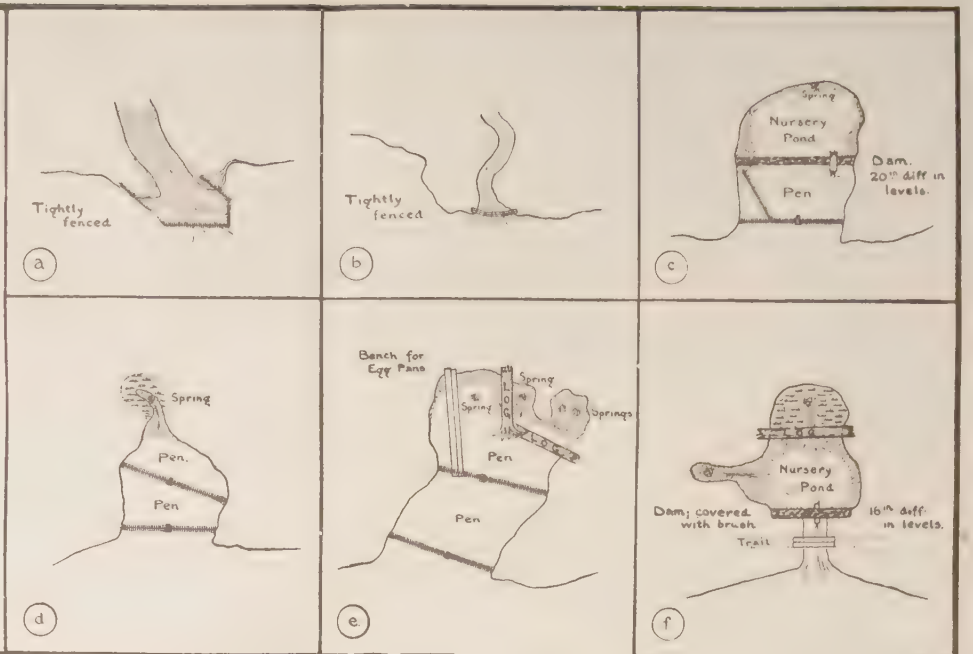
The hatchery usually opens July 1, when preparations are begun for the season; stripping generally commences September 1; the place is closed about March 1.

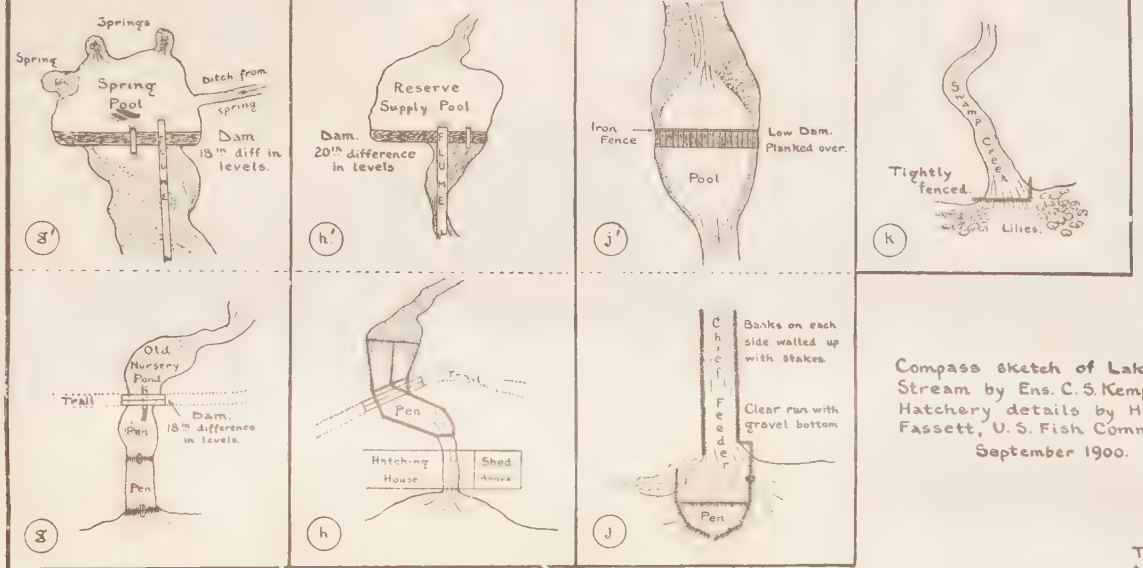
The hatchery building is 75 feet long, east and west, by 11 feet in width; south wall 11 feet high, north wall 6 feet high; shed roof, with windows on the south side only; on the east end is an open shed annex, 18 feet by 11 feet.

The troughs are 16 feet by 13½ inches by 5½ inches, inside measurement, made of planed lumber, 1½-inch bottom, 1¼-inch sides, covered with asphalt varnish. In the main building are 2 lines of troughs arranged in pairs, with 8 troughs in a line, making a total of 16, arranged with a passage around the lines as shown in the sketch. Each pair of troughs has a drop of 1 inch in its length, with a fall of 4 inches to the next. The first compartment in each trough is 8 inches in length, and receives and aërates the water; then come 7 basket divisions, each 24 inches long, separated by the Williamson system of division plates, 2 inches apart; the last space is 4 inches. The annex will accommodate 4 troughs, but it has seldom been used.

The baskets are of the usual wire webbing, five-eighths inch by one-sixth inch for redfish eggs, and five-eighths inch by one-fifth inch for cohoes, and are 23¾ inches by 12¾ inches by 4¾ inches, and have no wooden rims. They are supported an inch from the bottom of the trough by broad-headed nails and tin clips. All are well lacquered. A full basket contains 60,000 redfish eggs, or 30,000 to 35,000 coho eggs. The capacity of the hatchery is therefore 6,720,000 redfish eggs, and the annex 1,680,000 of the same species, but it is doubted if the latter can be regarded as a reliable factor in estimating the capacity.

Sketch-plan of hatchery and vicinity, with sub-sketches showing arrangement of feeders, nursery ponds, and pens.





Compass sketch of Lake and Stream by Ens. C. S. Kempff, U. S. N.
Hatchery details by H. C. Fassett, U. S. Fish Commission.
September 1900.

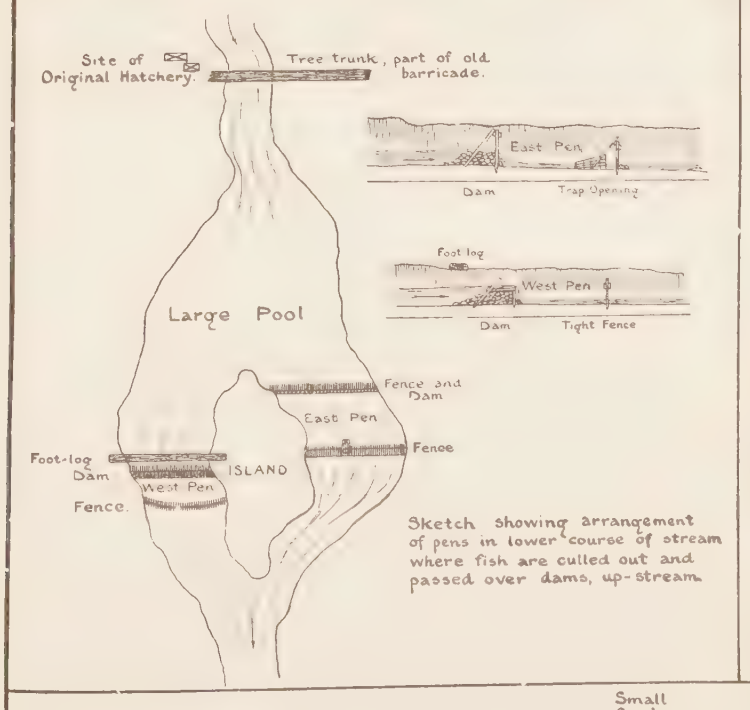
ALASKA
ETOLIN ISLAND

Sketch of
LAKE and STREAM
at the Head of

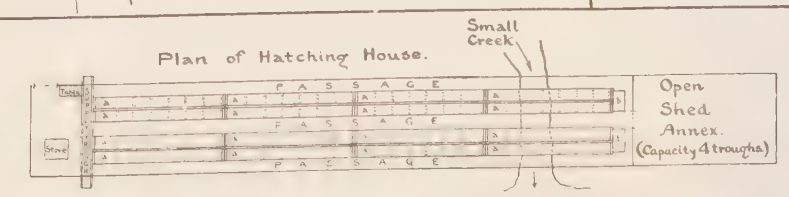
Mc HENRY INLET

showing location
of
Captain J. C. Callbreath's
SALMON HATCHERY.

0 ¼ ½ 1
Scale: 1 Nautical Mile.



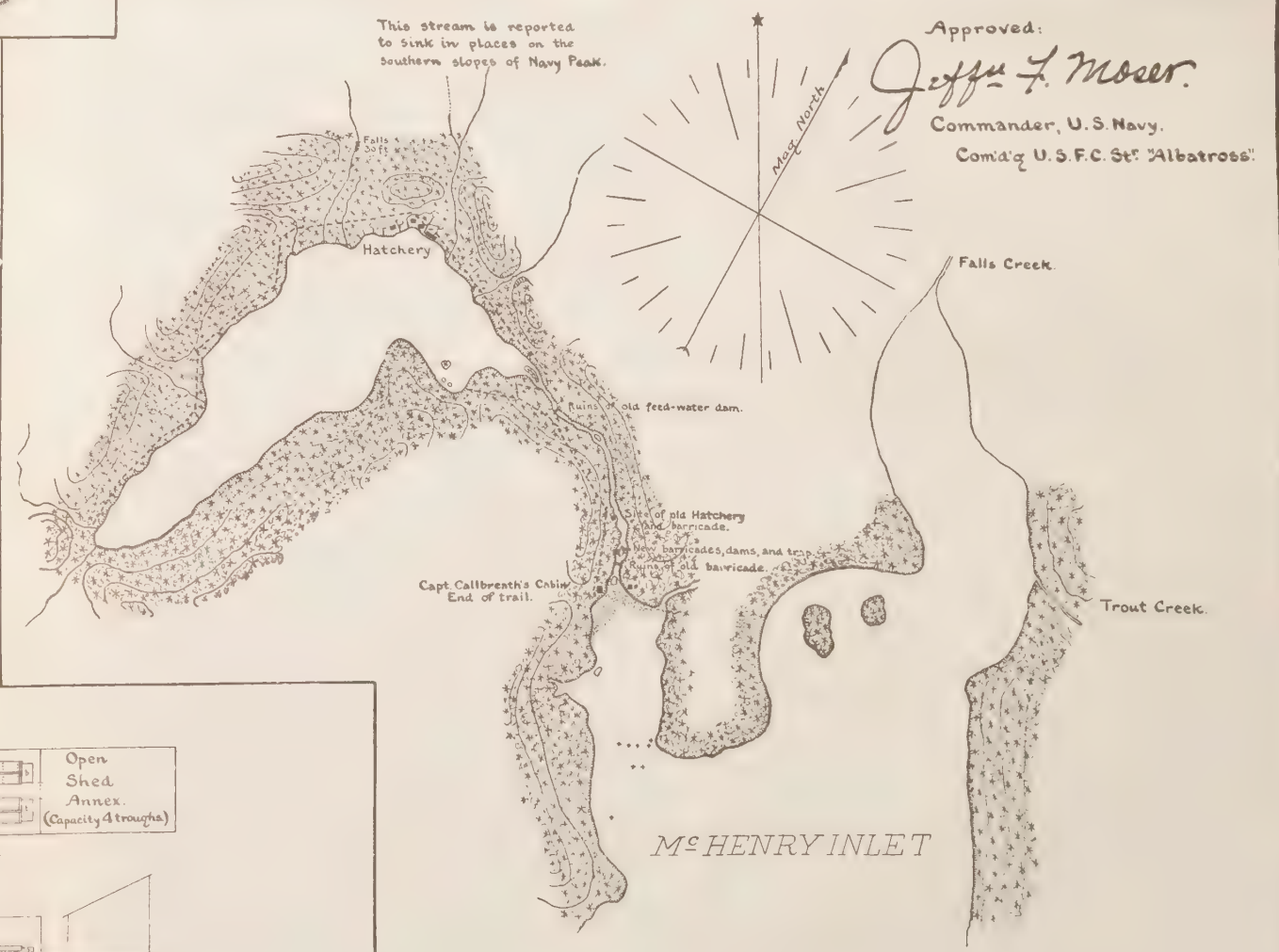
Sketch showing arrangement of pens in lower course of stream where fish are culled out and passed over dams, up-stream.



a. Hatching Troughs. b. Waste Troughs.

Section showing arrangement of troughs. Scale: 1/16 inch = 1 foot.

This stream is reported to sink in places on the southern slopes of Navy Peak.



Drawn by
H. C. Fassett

The hatchery water is received from a pool about 150 yards north of the hatchery, which is supplied by three springs (see sketch *g*) in the immediate vicinity, augmented by an additional spring, which is connected with the pool by a ditch. From the pool the water is conveyed by a covered flume to the west end of the hatchery building and is then distributed, as shown in plate XXIX. The flow is regulated at the closed end of the flume in the pool by means of holes in the bottom plank, in which plugs may be inserted, increasing or decreasing the supply as may be necessary. The main flume, midway in its length, is joined by a flume running from a reserve pool to the eastward, which may be used if necessary. The water is very clear and evidently quite pure, as no trouble has ever been experienced from fungoid growth. It is not filtered, but there are screens in the upper end of the flume to strain out foreign particles which may fall into the pool. The water is very equable in temperature and is said never to freeze. The lowest temperature observed in midwinter is recorded as 38° F., and the highest in midsummer 46° F. These are the extremes, the average range running from 39° to 45° F. During moderate winter weather the temperature of the water runs from 40° to 43° F.—never above the latter. While the temperature of the water is frequently taken during the season, there is no daily record from which curves may be drawn. The following may be noted as fair averages: July 25, 1898, 45° F.; September 14, 1898, 43° F.; lowest during the winter of 1898–99, 39° F.; April 15, 1899, 41° F. The lake water ranges from the freezing point in winter to 60° F. in midsummer. It is claimed that the present hatchery supply is sufficient for 15,000,000 eggs and that there are additional springs in the vicinity which, at small expense, can be utilized. In the hatchery the same water is used through four troughs, and if the annex is used, through five. It then passes by a sluice to the small creek under the hatchery.

The arrangements seem crude, and all fittings and appliances are constructed at the least expense, yet it all indicates an intelligent endeavor in a direction where there was but little previous experience in the work. Judging from the output, however, the hatchery has been very successful, and is a striking example of what may be done in this line of work if undertaken in an intelligent manner. Mr. Callbreath certainly deserves great credit, not only for the work he has accomplished, but for the proof he has given that a hatchery may be operated successfully for very little money.

Feeders, ripening pools, and nurseries.—The redfish and cohoes after entering the lake remain in its waters until ripe, a period varying from two to six weeks, sometimes longer, depending upon the condition of the fish as they enter from the sea; and when ripe they seek the feeders to spawn. In the immediate vicinity of the hatchery there are six feeders and springs which form natural spawning-beds and are arranged for taking ripe fish, and also several nursery ponds. The mouths of these feeders are fenced and have trap openings, which admit the fish, but do not permit them to leave.

Feeders *a*, *b*, and *k* are tightly fenced to prevent adult fish from entering, as they are full of obstructions on which the fish might injure themselves. *c*, *d*, *e*, and *f* are spring pools, which have been cleared and improved, opening on the lake. The pool *c* is separated by a dam into two ponds, the inner one forming an excellent nursery. *d* is not considered very good. *e* is the best pond, and secures

the largest number of breeders except *j*. *f* is a nursery pond; an inclined fence of brush surmounts the dam and partly shades the pool, which is believed to benefit the fry. *g* is the outlet for the overflow from the hatchery reservoir pool; it has several small pools, formed by widenings in the stream, where fry were one year planted but did not do very well. The lower of these pools, shown on the sketch, was also used as a nursery, but was unsatisfactory. *h* is the overflow from the auxiliary pool for hatchery supply, and receives the hatching-house waste; at times a few fish are permitted to enter and are spawned as needed to fill up baskets. *j* is the chief feeder entering the lake, and is about 100 yards east from the hatchery; the mouth is fenced with the usual trap opening, and from this point for about 70 feet upstream the banks are walled up with vertical slabs. At *j'* the stream has been dammed to make an upper pool in which, and in the upper reaches, fry are released. The ripe fish are stripped on the west bank of the lower reach.

Spawning.—The ripe fish enter the pens through the traps and are taken by dip nets; they average about 7 pounds in weight. Spawning begins about September 1, and continues actively for about six weeks; a few ripe fish keep running until late in the winter, the latest arrivals having the most perfect eggs.

In spawning the wet process is used; a pan is half filled with water, into which the ova are stripped and the milt added; these are mixed with the fingers, and then set aside for one hour, after which the eggs are thoroughly washed, transferred to buckets, and carried to the hatchery where they are placed in the baskets.

It is found that impregnation will take place up to 3 minutes after the ova have been ejected, and that the best results are obtained by adding the milt between ½ and 1½ minutes after ejection.

Size of eggs.—The number of eggs of both redfish and cohoes has been frequently counted, and it has been found that a full healthy female of each species contains 3,500 eggs, but it is rare that the full number is obtained. As frequently some are left in the fish, and others are not in good condition, the count is made on 3,000 eggs to the full fish, or 20 redfish, or 10 to 12 cohoes, to the basket, the eggs of the latter being about twice the size of the former. When a large number of fish mature at the same time it is frequently found that some eggs have been voided, and in such cases it will take two and sometimes three fish to make one "count" fish.

In counting the eggs a condensed-milk can is used as a measure. This measure, by repeated counting, has been found to contain 1,904 redfish or 848 coho eggs. A quantity of eggs from a healthy, normal, ripe female redfish was secured and measured with the following results: Forty covered 2 square inches and 20 in a line against a straight edge occupied a length of exactly 4½ inches, giving a single egg a diameter of 0.225 inch. It has been observed that brilliantly colored or unusually large or small eggs are apt to prove failures.

Several hundred cohoes are usually stripped each year and the eggs hatched. They run about six weeks later than the redfish.

The picking of eggs is done with ordinary tin forceps and is commenced six to eight weeks after the eggs are placed in the baskets. It is claimed that the percentage of bad eggs is very small, and that very little, if any, fungus appears. The delicate period is unknown here. It is probably covered during the time the eggs remain undisturbed.

Period of incubation.—The temperature records are not at all complete, and no attempt has been made to determine the thermal hatching unit. Generally it may be said that with a temperature of 45° F., the average highest, to 39°, the average lowest, the eye-spots appear in from 30 to 38 days. A few are earlier, and a few are 45 days before they are well eyed out. In 90 days they are hatching rapidly; in 100 days two-thirds are hatched; in 110 days four-fifths are out, and the remainder straggle along for several months. As the hatchery closes March 1 the unhatched eggs are buried in the gravel, simulating the natural conditions. The cohoes hatch about 10 days earlier, and an experiment made with a basket of humpback eggs showed that they hatched in 70 days under conditions in which the redfish hatched in 90 days.

Eggs which hatch out well in advance of the mass ("prematures") and those equally late, produce usually very weak fish or "freaks." It has been the experience here that it is useless to waste time on these fish, as they invariably die. It has been found that the fry just hatched collect in the lower end of the troughs, and to prevent loss they are removed as early as possible, within a day or two after hatching, and placed in the nursery, the upper ponds of the feeders, and sometimes in the lake, where the bottom is grassy or covered with pond lilies.

The yolk-sac is absorbed in from forty-five to fifty days, but shows plainly at sixty days, though skinned over and in the belly. After this has taken place they are taken from the nursery and some are placed in the feeders and others in the lake, where the natural conditions are most favorable for their protection.

The loss varies from 8 to 12 per cent, depending upon the season; if there is an abundance of rain, permitting the fish to ascend without injury, the eggs are found in good condition and the loss is small. During a dry season the fish are kept from ascending until the fall rains, and as they partially ripen in the salt or brackish water the eggs are more easily injured. Realizing the advantage in having the fish arrive in the lake in a healthy, vigorous state, considerable work has been done at the outlet to remove obstructions and to improve the natural conditions.

Barren lakes.—Mr. Callbreath lays considerable stress upon the use of what he terms barren lakes in connection with hatchery work. These lakes have in their sea connections high falls or cascades preventing the passage of fish from the sea and usually are quite clear of the enemies of salmon fry. Mr. Callbreath has planted redfish fry in two of these barren lakes, both discharging their water into Burnett Inlet. In 1894 and 1896, 1,000,000 redfish fry were planted each year in Burnett Lake, about 13 miles from the hatchery, and in 1895, 2,000,000 redfish fry were planted in Francis Lake, about 11 miles from the hatchery. The following coho fry have been planted in Falls Creek, previously referred to: 1893, 66,000; 1894, 50,000; 1896, 135,000; 1899, 60,000. The rest of the hatchery output has been planted in the home lake and feeders. The fry are transported as soon after hatching as the weather permits and before the egg sac is absorbed, as they then require fewer changes of water. Coal-oil cans are used for transportation cans; a screw-top mouthpiece, 1¼-inch opening, is soldered to the top of the can and the fry are poured in through a funnel having a large opening. A 5-gallon can will hold 30,000 redfish fry, or about 15,000 coho fry, and two such cans placed in the original case make a load for one man carried on the back with pack straps and, if the weather is cold, wrapped in blankets.

The following data, representing the output from this hatchery from July, 1892, to September, 1900, was furnished by Mr. Callbreath:

Year.	Redfish.					Cohoes.				
	Number adults passed over dam.		Total number of fry hatched.	Number of fry planted and locality.		Number adults passed over dam.		Total number of fry hatched.	Number of fry planted and locality.	
	Males.	Females.		Hatchery lake.	Other lakes.	Males.	Females.		Home lake.	Falls Creek.
1892	[1] 3,000	([2])	600,000	600,000	.....	.....	.....	.....	.....	.....
1893	[1] 3,010	([2])	1,888,000	1,888,000	.....	[1] 1,151	([2])	416,000	350,000	66,000
1894	2,438	2,016	4,928,000	3,928,000	[3] 1,000,000	256	230	363,000	313,000	50,000
1895	2,799	2,497	4,960,000	2,960,000	[4] 2,000,000	134	204	515,000	515,000	.....
1896	1,617	2,008	3,880,000	2,780,000	[3] 1,100,000	374	338	510,000	375,000	135,000
1897	1,817	1,572	2,000,000	2,000,000	.....	590	500	526,000	526,000	.....
1898	1,189	821	1,800,000	1,800,000	.....	158	142	250,000	250,000	.....
1899	1,058	1,175	1,385,000	1,385,000	.....	991	963	950,000	890,000	60,000
	10,918	10,089	21,441,000	17,341,000	4,100,000	2,503	2,377	3,530,000	3,219,000	311,000
1900	1,991	1,863	None stripped; fish allowed to seek natural spawning beds.			526	482	None stripped; fish allowed to seek natural spawning beds.		

[1] Both sexes; not included in total. [2] Not known. [3] To Burnett Lake. [4] To Francis Lake.

In this record it should be remembered that the number of fish passed over the dam is not the number stripped. The number recovered for spawning purposes varies so much that no percentage can be stated, and what becomes of those not stripped is a mystery to the hatchery people. For instance, in 1899 there were passed over the dam between July 16th and October 26th 1,175 female and 1,058 male redfish, a total of 2,233, and from August 29th to November 14th 963 female and 991 male cohoes, making a total of 1,954; of this number 1,367 redfish and 1,231 cohoes were recovered; this includes not only all spawned fish, but all found dead along the shores after diligent and repeated search.

The following experience at the hatchery may be of interest and worthy of record: On September 23, 1898, about 20 spawners were allowed to enter one of the hatchery ponds and spawn. On April 13, 1899, nearly seven months later, these spawning-beds were turned over and a number of young fish found with the egg-sac not yet absorbed. The same run of fish stripped and hatched in the troughs had the egg-sacs absorbed two months prior to that time. It is the opinion at the hatchery that the young go to sea in from 10 to 15 months after they are hatched, though some remain in the lake until they are from 20 to 24 months old.

Mr. Callbreath is positive that his fish will return, but he now believes the time has not yet arrived for the first output to mature. It is earnestly hoped he may realize all he anticipates, for the zeal and enthusiasm which he displays should meet with ample reward. In the meantime he is carrying on a very interesting experiment; if his fish return he will have demonstrated that salmon *do return to the parent stream*, he will have thrown much light on the age of fish, and he will have proved that a stream running a few fish can be made to yield abnormally. If this is demonstrated a law should be passed permitting the leasing of small streams for hatchery purposes and recognizing ownership in fish thus hatched. This would mean a great deal to southeastern Alaska, as it would draw settlers who could make a very good living by operating a hatchery and cultivating the little patches of land that are favorably located.

HALIBUT FISHERIES OF SOUTHEASTERN ALASKA.

Since my former report on this subject, pages 45 to 48, there has been no development of any halibut banks in this section, but the spots in which these fish occur have been utilized by small boats in a manner that has made them profitable.

A few years prior to 1899 the fresh-halibut fishery was conducted by a few small schooners and sloops, chiefly from Puget Sound, which shipped the iced product by freight steamers to the Sound market from Wrangell. The fishing, however, was desultory, and could hardly have been called profitable until 1899, when the Icy Strait Packing Company completed their wharf at Petersburg, near the upper end of Wrangell Narrows, and arranged with a steamship company to make regular calls for freight. Under this arrangement it was agreed that the halibut boats of Chatham Strait and Frederick Sound should ship from the new station. During the first winter, from October, 1899, to March, 1900, about 20 small schooners and sloops of from 5 tons to 20 tons formed the fleet, calling regularly at Petersburg with fresh halibut for shipment. The fish were obtained chiefly in Chatham Strait and Frederick Sound. Twelve of these vessels averaged 2 dories and 5 men, and 8 averaged 1 dory and 3 men, making a total of 32 dories and 84 men, each of whom may be said to have had a personal interest in a vessel. From October, 1899, to April, 1900, the Icy Strait Packing Company also engaged in the halibut fisheries, employing their cannery steamers for this purpose. The steamer *White Wings*, 34 tons, valued at $7,000, besides her regular winter crew of 4, carried 8 deck-hands and fishermen, working 4 dories; and the steamer *Annie M. Nixon*, 18 tons, valued at $6,000, in addition to her crew of 4, employed 6 fishermen, working 3 dories. The fishermen received board and 20 cents per fish of more than 15 pounds weight. The fish averaged 40 pounds, dressed. The largest weighed 250 pounds. The catch for the season of the Icy Strait Packing Company amounted to 700 boxes of fresh halibut iced, 500 pounds net weight per box, and was shipped to Seattle and sold at an average price of 3 cents per pound. It is said that the 20 small craft engaged in the fishery each averaged 40 boxes of fresh halibut per month, making 200 tons per month.

It may therefore be said that there were employed on these halibut fisheries from October, 1899, to the end of March, 1900, two small steamers and 20 small sail vessels, using 39 dories and employing 98 fishermen.

The ice used is gathered from the neighboring glaciers, and if ground in a mill made for the purpose is in the best form, though many merely break it into fine lumps with a club.

As mentioned in my former report, no great banks where halibut occur in such numbers that a seagoing vessel may make a load and return to market have yet been found in Alaska, but there are many spots on which halibut may be found, and fishing from small vessels convenient to a steamer route, as outlined above, seems to offer the best means for conducting these fisheries successfully.

It is possible that these fisheries will increase in importance until the spots are cleaned off, when some other field will be sought until the grounds recuperate. At present it is promising enough to attract the attention of many small fishers from the Sound country. The gear used consists of bottom trawls and long hand lines; it is simple and inexpensive.

GENERAL CONDITIONS.

THE LAW.

During the investigation of the salmon fisheries in Alaska in 1897, when this vessel visited all the operating canneries and fisheries outside of Bering Sea, it was my opinion, frequently expressed, that as a rule the streams were overfished and could not continue for a long period to withstand the enormous draft made upon them.

These fisheries have grown to such an extent that unless one has been in constant touch with the subject, the situation can not be fully grasped. In 1878, when the first canneries were established, the total Alaska pack was 8,159 cases; seven years later, in 1885, the pack was 83,415 cases; only four years afterwards, in 1889, the pack had grown to be 719,196 cases; and seven years from that date, 1896, it was 966,707 cases; followed by a slack year, 1897, which yielded 909,078 cases. The past season, however (1900), has exceeded even the canners' expectations, and an output of 1,548,139 cases was the result. Multiplying this number by 85 may give approximately the number of pounds of live salmon taken from the Alaska streams by the canneries. This does not include the amount taken by the salteries, or by the whites and natives for their own local use. It may be imagined how prolific these rivers must be when, under any condition, they can furnish this mass of fish. Every means that man can devise is used for their capture and apparently without restriction.

In my former report, pages 38–42, the subject of the law was briefly discussed, and, with the experience since obtained, there seems no reason for changing the recommendations then made, but, on the contrary, they should be emphasized and augmented. My opinion of traps has been given previously and need not be repeated here, except to say that, whatever legislation is effected, there should be no exceptions made.

During the past three years so-called purse seines have grown in favor, particularly in southeastern Alaska, and it is now claimed by those operating them that it is no longer necessary to resort to barricades, as the purse seines take all the fish before they can enter the streams. These seines are simply deep drag seines, square hung, which, in hauling, are pursed by gathering in the foot rope. Around the larger and more prolific streams of southeastern Alaska, such as Hetta, Karta Bay, and Quadra, there were from 25 to 30 of these seines in operation during the season of 1900, one seine following the other in such rapid succession that few fish escaped capture. Purse seines, or seines used as such, should be abolished; in fact, the only fishing apparatus allowed should be gill nets and drag seines; no exceptions should be made. The use of these appliances should be regulated, and competent inspectors appointed to enforce the law and the regulations.

In the small streams examined this year those away from the lines of travel were all found to have evidences of barricading. In some, where the current is not very strong, stakes, planted on the banks and in the stream bed to support a net held to the bottom by bowlders, answered the fishermen's purpose, while in other cases the regular log barricade, referred to in my previous report, was strongly in evidence.

Since it is believed that the Puget Sound and Columbia River salmon fisheries are failing, attention has been drawn to Alaska. Six new canneries appeared in

southeastern Alaska during 1900, generally small in their appointments, prepared to make a hand pack of 12,000 to 20,000 cases for the season. It is confidently expected, if the labor can be obtained, that from 15 to 20 additional ones will be located throughout Alaska in 1901, and all of the older canneries expect to increase their capacity. It is hardly necessary for me to say that the fisheries can not support all these canneries, at the present rate, for any length of time; they will surely become exhausted for extensive commercial purposes.

There is another point which should receive the attention of the law, and that is the inspection of the product put in the cans and of the labeling. Compared with the large amount of salmon that reaches the market, the quantity that might be called unfit bears a very small proportion. Yet salmon that should not be consumed are packed under misleading labels, and the law should prohibit it. The law also should require the canner to plainly label every can he produces with the species of fish in the can, the quality, and the location of the cannery packing. The number of different labels now used on the Pacific coast is very large; a list before me from one lithographic company represents 702. From this it may be inferred that even an expert finds difficulty in telling the quality of the goods covered by a label. It was noticed in some of the new canneries that frequently a low grade of fish was covered by the most brilliant of labels, and in one instance—though doubtless there are others—dog salmon were covered by "Fresh Columbia River salmon." Such practices must throw discredit upon all goods, and one would fancy that reputable canneries would ask protection against it.

It is my opinion that a section of the law should provide for a certain time when fishing for redfish may commence, and prohibit their capture before that time. The object of this close season is to permit all the earliest arrivals to ascend to the lakes, where they may spawn early and have the eggs hatched before the cold weather sets in. It is probable that many of the feeders, used as spawning-beds, freeze to the bottom during the winter, and the late eggs must necessarily be destroyed. No one appreciates the difficulty in framing such a law more than the writer; but it is not impracticable, and with the data now at hand it is entirely feasible. Take, for example, southeastern Alaska. We know that all redfish packed from the earliest arrivals to about July 4 hardly pay cannery expenses. This does not take into account the small pack of king salmon, made by a few canneries, from the Chilkat, Taku, Stikine, and Unuk. A law, therefore, prohibiting the capture of redfish in southeastern Alaska before July 4 would be an excellent provision, and other districts could be treated in a similar manner. In order to execute the law, might it not be well to pay informers one-half of all fines collected?

With the large accessions of canneries in Alaska the struggle in the fisheries is sure to increase, and every means will be employed for the capture of fish regardless of the law, unless the Government enforces it by an efficient and intelligent inspection. The future, even more than the past, requires efficient inspection, which, however can not be realized under the present conditions.

STATISTICS.

Comparison table of the salmon packing industry of the Pacific coast, from its first inception in 1866 to 1900.

[Compiled from various sources.]

Year.	Alaska.	British Columbia.	Puget Sound.	Outside rivers.	Columbia River.	Sacramento River.	Total.
1866					4,000		4,000
1867					18,000		18,000
1868					28,000		28,000
1869					100,000		100,000
1870					150,000		150,000
1871					200,000		200,000
1872					250,000		250,000
1873					250,000		250,000
1874					350,000	2,500	352,500
1875					375,000	3,000	378,000
1876		9,847		25,600	450,000	8,300	493,747
1877		67,387		24,800	460,000	21,500	573,687
1878	8,159	113,601		30,000	460,480	36,500	648,740
1879	12,530	57,394		30,000	480,000	31,000	610,924
1880	6,539	61,300		37,200	630,000	51,000	786,039
1881	8,977	175,675		48,500	551,000	181,200	965,352
1882	21,745	255,061		49,000	541,360	200,300	1,067,466
1883	48,337	243,000		38,000	629,400	160,000	1,118,737
1884	63,886	138,945		41,350	656,179	81,450	981,810
1885	83,415	106,865		51,750	524,530	48,500	815,060
1886	142,065	163,004		131,100	454,943	39,300	930,412
1887	206,677	201,990		195,400	373,800	36,500	1,014,367
1888	412,115	135,600		154,000	367,750	61,200	1,130,665
1889	719,196	414,400		199,068	325,500	66,666	1,724,830
1890	682,591	409,464		67,117	433,500	25,065	1,617,737
1891	801,400	314,813		78,305	390,185	10,353	1,595,056
1892	474,717	236,997		129,000	502,800	2,281	1,345,795
1893	643,654	637,120		105,309	375,700	23,336	1,785,119
1894	686,440	562,371		103,340	511,000	28,463	1,891,614
1895	626,530	564,877		205,500	627,500	25,185	2,049,592
1896	966,707	598,300	248,200	115,400	463,621	13,387	2,405,615
1897	909,078	1,015,477	423,500	68,683	552,721	38,543	3,008,002
1898	965,097	454,500	417,700	78,600	473,230	29,731	2,418,858
1899	1,078,146	711,600	871,500	82,432	340,125	33,227	3,117,030
1900	1,548,139	527,281	478,742	106,300	313,417	39,304	3,013,183
Total	11,116,140	7,176,869	2,439,642	2,195,754	13,613,741	1,296,791	38,839,937

NOTE.—Prior to 1896 the Puget Sound pack is included under "Outside rivers." The pack is given in cases of 48 one-pound tins.

Table showing by years the number of salmon canneries operated in each district of Alaska, from 1878 to 1900, with the annual per cent value of total salmon pack (canned) for each district.

Year.	Southeast Alaska.		Prince William Sound and Copper River.		Cook Inlet.		Kadiak and Chignik.		Bering Sea.		Total number of canneries.
	No. of canneries.	Annual per cent of total salmon pack.	No. of canneries.	Annual per cent of total salmon pack.	No. of canneries.	Annual per cent of total salmon pack.	No. of canneries.	Annual per cent of total salmon pack.	No. of canneries.	Annual per cent of total salmon pack.	
1878	2	100									2
1879	2	100									2
1880	1	100									1
1881	1	100									1
1882	1	52.9			1	27.8	1	19.3			3
1883	4	39			1	32	1	29			6
1884	4	31.5			1	34.7	1	33.1	1	0.7	7
1885	3	14			1	24.8	1	43.2	1	18	6
1886	4	12.8			1	20.1	1	32.6	3	34.5	9
1887	5	15.2			1	14.9	1	34.7	3	35.2	10
1888	6	19.7			2	10.3	4	48.2	4	21.8	16
1889	12	19.1	4	3.4	2	7.1	15	54.2	4	16.2	37
1890	12	20.9	3	6.2	2	4.2	14	51.3	4	17.4	35
1891	11	19.5	3	8.5	3	7.4	8	48	5	16.6	30
1892	7	24.4		0	1	4.3	5	57.9	2	13.4	15
1893	8	21.1	3	12	1	4.9	7	45.2	3	16.8	22
1894	7	20.8	3	11.4	1	5	6	47	4	15.8	21
1895	7	23.7	3	9.6	1	5.7	6	37.1	6	23.9	23
1896	9	27.1	3	9.6	1	3.6	8	37.1	8	22.6	29
1897	9	29.9	2	5.7	1	3.6	10	32.8	7	28	29
1898	9	26.1	2	6.3	2	5.8	10	28.7	7	33	30
1899	9	28.8	2	5.7	2	4.8	10	22.5	9	38.2	32
1900	16	29.5	2	4.5	3	4.1	9	23.2	12	38.7	42
Percentage of gross pack for 23 years		24.9		6.2		6		37.5		25.4	

Complete table of Alaska salmon (canned) pack, by canneries and di

[One case contains 48 pou

Name of company and location of cannery.	Owned in 1900 by—	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Southeast Alaska.										
North Pacific Trading and Packing Co., Klawak	Same company	*Cases.* 5,402	*Cases.* 6,675	*Cases.* 6,539	*Cases.* 8,977	*Cases.* 11,501	*Cases.* 8,240	*Cases.* 6,189	*Cases.* 8,428	*Cases.* 7,860
Cutting Packing Co., Old Sitka, Baranof Island	Defunct	2,757	5,855	Closed.		[2] Abandoned.				
Cape Fox Packing Co., north shore, Boca de Quadra	do						2,000	3,000	5,900	500
Tongass Packing Co., Ketchikan, Tongass Narrows	do									
Chilkat Packing Co., east shore, Chilkat Inlet	do						6,000	7,000	2,400	1,700
Northwest Trading Co., Pyramid Harbor	do						3,800	6,000	Closed.	8,600
Pyramid Harbor Packing Co., Pyramid Harbor	Alaska Packers Association									
Aberdeen Packing Co., Lower Stikine River	Defunct									
Glacier Packing Co., Point Highfield, Wrangell Island	Alaska Packers Association									
Alaska Salmon Packing and Fur Co., Loring	do									
Cape Lees Packing Co., Burroughs Bay	Defunct									
Boston Fishing and Trading Co., Yes Bay	Same company									
Baranoff Packing Co., Redoubt, Baranof Island	Defunct									
Baranoff Packing Co., Redfish Bay, Baranof Island	do									
Astoria and Alaska Packing Co., Freshwater Bay	do									
Astoria and Alaska Packing Co., Point Ellis, Kuiu Island	do									
Bartlett Bay Packing Co., Bartlett Bay	do									
Chilkat Canning Co., Chilkat Village, Chilkat Inlet	Alaska Packers Association									
Metlakahtla Industrial Co., Metlakahtla	Same company									
Quadra Packing Co., Mink Arm, Boca de Quadra	Icy Strait Packing Co									
Pacific Steam Whaling Co., Hunter Bay	Same company									
Thlinket Packing Co., Gerard Point, Eastern Passage	do									
Fidalgo Island Canning Co., Ketchikan	do									
Royer-Warnock Packing Co., Beecher Pass	do									
Icy Strait Packing Co., Petersburg, Wrangell Narrows	do									
Taku Fishing Co., Port Snettisham	do									
Taku Packing Co., Taku Inlet	do									
Western Fisheries Co., Dundas Bay	do									
Chilkoot Packing Co., Chilkoot Inlet	do									
Total of annual packs in Southeast Alaska		8,159	12,530	6,539	8,977	11,501	20,040	22,189	16,728	18,660
Prince William Sound and Copper River.										
Central Alaska Co., Little Kayak Island	Defunct									
Peninsula Trading and Fishing Co., Little Kayak Island	do									
Peninsula Trading and Fishing Co., Coquenhena	do									
Pacific Packing Co., Odiak	Alaska Packers Association									
Pacific Steam Whaling Co., Odiak	Defunct									
Pacific Steam Whaling Co., Orca	Same company									
Total of annual packs in Prince William Sound and Copper River										
Cook Inlet.										
Alaska Packing Co., Kussilof River	Defunct					6,044	14,818	21,141	Transf. to new co.	
Arctic Fishing Co., Kussilof River	Alaska Packers Association								19,217	28,43
Northern Packing Co., Kenai, Kaknu River	do									
George W. Hume, Kussilof River	Defunct									
Pacific Steam Whaling Co., Kenai, Kaknu River	Same company									
Alaska Salmon Association, Chuitna River	do									
Total of annual packs in Cook Inlet						6,044	14,818	21,141	19,217	28,43

[1] Burnt September 18, 1899; rebuilt spring of 1900 on new site.
[2] Machinery moved to Arctic Packing Co., Kussilof River.
[3] Burnt in August, 1889.
[4] Burnt and rebuilt in spring.
[5] Machinery moved to Egega
[6] Hand pack; machinery inst
[7] Machinery moved to Pyram
[8] Experimental pack.

cts, from its earliest inception in 1878 to close of season of 1900.

f salmon, net weight.]

887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total.
ases.	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*
9,562	12,325	11,370	10,188	9,256	10,194	12,595	14,455	12,228	16,675	15,705	16,307	19,100	[1]27,752	267,523
														8,612
ld;														11,400
oved.														29,500
5,500	11,000	[3]13,000												66,969
8,000	Closed.	13,500	15,000	13,369	Burnt.									23,400
5,000	Transf. to new co.													
	19,300	[4]13,400	12,300	18,300	28,964	13,668	38,781	35,373	47,456	37,456	39,669	53,237	55,601	413,505
3,100	14,000	Sold; moved.												17,400
		13,800	14,600	15,876	Closed.	22,728	25,250	27,416	44,233	45,918	49,332	50,201	58,518	367,872
	18,771	28,862	23,024	22,786	21,446	25,153	26,869	32,554	61,467	62,040	59,343	63,390	67,158	512,863
	5,732	10,574	10,823		Closed.		Dismantled.							27,129
		4,500	9,343	17,365	13,734	15,102	12,000	14,100	24,100	22,300	15,174	25,504	33,623	206,845
		4,454	10,123	Moved.										14,577
				7,949	10,259	9,889	11,189	14,805	15,358	14,070	12,681	[5]Abandoned.		96,200
		5,000	Moved.											5,000
			8,000	16,200	Burnt May 1.									24,200
		[6]4,300	12,000	7,600	Closed.		[7]Dismantled.							23,900
		19,000	17,000	20,914	20,000	24,418			Closed; in reserve.					101,332
			[8]500	7,000	11,125	12,500	14,000	12,000	17,650	15,490	11,671	12,322	17,560	131,818
									8,000	24,500	16,000	37,000	13,600	99,100
									27,442	34,388	31,208	38,265	43,607	174,910
												11,200	25,640	36,840
													27,256	27,256
													1,560	1,560
													29,941	29,941
													9,458	9,458
													16,722	16,722
													13,793	13,793
													14,850	14,850
1,462	81,128	141,760	142,901	156,615	115,722	136,053	142,544	148,476	262,381	271,867	251,385	310,219	456,639	2,774,475
		1,600	[9]Moved.											1,600
		2,540	14,200	Moved.										16,740
				18,085	Closed.	15,270	15,000	15,000	20,672	Closed.	[10]Abandoned.			84,027
		5,064	13,716	27,209	Closed.	28,999	28,378	21,453	39,873	23,301	32,158	31,931	39,410	291,492
		15,000	14,278	22,797	Closed.	32,729	35,285	Moved.						120,089
								23,041	32,321	28,756	28,668	29,864	30,588	173,238
		24,204	42,194	68,091	None.	76,998	78,663	59,494	92,866	52,057	60,826	61,795	69,998	687,186
														42,003
0,765	29,455	31,782	[11]Closed.	19,157	Closed.	31,665	34,033	36,188	34,767	32,532	39,566	28,815	33,781	430,156
	12,996	18,712	15,905	18,254				Closed; in reserve.						65,867
			12,750	21,586	20,741	Closed.		[12]Dismantled.						55,077
											16,876	23,300	25,089	65,265
													4,905	4,906
0,765	42,451	50,494	28,655	58,997	20,741	31,665	34,033	36,188	34,767	32,532	56,442	52,115	63,775	663,273

king Co., Egegak River.
n 1890.
rbor Packing Co., Pyramid Harbor.

[9]Moved to Thin Point, Alaska Peninsula.
[10]Machinery moved to Pacific Steam Whaling Co., Kenai.
[11]Transport vessel wrecked and outfit lost.
[12]Consolidated with Arctic Fishing Co., Kussilof River.

Complete table of Alaska salmon (canned) pack, by canneries and districts,

[One case contains 48 pound

Name of company and location of cannery.	Owned in 1900 by—	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Kadiak and Chignik.		*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases*	*Cases.*	*Cases.*
Karluk Packing Co., Karluk, Kadiak Island	Alaska Packers Association					4,200	13,479	20,156	33,470	46,150
Kodiak Packing Co., Karluk, Kadiak Island	do									
Aleutian Islands Fishing and Mining Co., Karluk	Defunct									
Hume-Aleutian Packing Co., Karluk, Kadiak Island	Alaska Packers Association									
Arctic Packing Co., Larsen Cove, Uyak Bay, Kadiak Island	Defunct									
Royal Packing Co., Afognak Bay, Afognak Island	Alaska Packers Association									
Russian-American Packing Co., Afognak Bay, Afognak	do									
Hume Packing Co. Karluk, Kadiak Island	do									
Alaska Improvement Co., Karluk, Kadiak Island	do									
Arctic Packing Co., Olga Bay, Alitak, Kadiak Island	do									
Kodiak Packing Co., Snug Harbor, Alitak, Kadiak Island	do									
Chignik Bay Co., Chignik Lagoon, Alaska Peninsula	do									
Shumagin Packing Co., Chignik Lagoon	Defunct									
Chignik Bay Packing Co., Chignik Lagoon	Alaska Packers Association									
Western Alaska Packing Co., Ozernoi, Stepovak Bay	Defunct									
Thin Point Packing Co., Thin Point, Alaska Peninsula	do									
Central Alaska Co., Thin Point, Alaska Peninsula	do									
Hume Canning and Trading Co., Tanglefoot Bay, near Karluk	Alaska Packers Association									
Uganuk Fishing Station, Uganuk Bay, Kadiak Island	do									
Pacific Steam Whaling Co., Anchorage Bay, Chignik	Same company									
Hume Bros & Hume, Anchorage Bay, Chignik	do									
Pacific Steam Whaling Co., Uyak Bay, Kadiak Island	do									
Hume Bros. & Hume, Uyak Bay, Kadiak Island	do									
Total of annual packs in Kadiak and Chignik						4,200	13,479	20,156	33,470	46,150
Bristol Bay, Bering Sea.										
Arctic Packing Co., Nushagak Bay	Alaska Packers Association							[16]400	14,000	19,000
Alaska Packing Co., Nushagak Bay	do									16,500
Bristol Bay Canning Co., Nushagak Bay	do									13,322
Nushagak Canning Co., Nushagak Bay	do									
Bering Sea Packing Co., Ugashik River	Defunct									
Arctic Packing Co., Naknek River	Alaska Packers Association									
Naknek Packing Co., Naknek River	Same company									
Point Roberts Packing Co., Koggiung, Kvichak Bay	Alaska Packers Association									
Ugashik Fishing Station, Ugashik River	do									
Pacific Steam Whaling Co., Nushagak Bay	Same company									
Alaska Fishermen's Packing Co., Nushagak Bay	do									
Kvichak Packing Co., Kvichak Bay	Alaska Packers Association									
Egegak Packing Co., Egegak River	do									
Bristol Packing Co., Ugashik River	Same company									
Total of annual packs in Bristol Bay, Bering Sea								400	14,000	48,822
Recapitulation.										
Southeast Alaska		8,159	12,530	6,539	8,977	11,501	20,040	22,189	16,728	18,660
Prince William Sound and Copper River						6,044	14,818	21,141	19,217	28,433
Cook Inlet						4,200	13,479	20,156	33,470	46,150
Kadiak and Chignik								400	14,000	48,822
Bristol Bay, Bering Sea										
Grand total of annual packs in Alaska		8,159	12,530	6,539	8,977	21,745	48,337	63,886	83,415	142,065

[1] Packed in cannery of Hume Packing Co., Karluk.
[2] Consolidated with Hume Packing Co., to form the Hume-Aleutian Packing Co., Karluk.
[3] Packed in cannery of Kodiak Packing Co., Karluk.
[4] Machinery moved to Uganuk Fishing Station, Uganuk Bay.
[5] Rendered inoperative by President's proclamation creating a Fish Commission reservation on Afognak Island.
[6] Packed in cannery of Alaska Improvement Co., Karluk.
[7] Machinery moved to Ugashik Fishing Station
[8] Buildings moved to Uganuk Fishing Station,
[9] Consolidated with Aleutian Islands Fishing Co., Karluk.
[10] Moved to new site on same bay.
[11] Part of machinery moved to Karluk.
[12] Packed in cannery of Chignik Bay Co., Chign

om its earliest inception in 1878 to close of season of 1900—Continued.

salmon, net weight.]

7.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	Total.
28.	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*	*Cases.*
750	101,304	62,057	40,306	66,483	75,416	59,220	79,000	48,379	68,495	54,777	28,898	31,210	79,415	984,165
....	26,146	30,287	43,060	41,000	Closed.	30,138			Closed; in reserve.					170,631
....	33,700	53,551	40,335	[1]39,312	[2]Consolidated.									166,898
....					76,233	59,959	79,000	47,500	70,320	49,633	24,398	18,987	Closed.	426,030
....	37,500	44,200	37,600	[3]41,000	Closed.				[4]Dismantled.					160,300
....		16,412	9,926			[5]Closed.			[4]Dismantled.					26,338
....		25,500	26,500	[6]25,000		[5]Closed.		[7]Dismantled.	[8]Abandoned.					77,000
....		28,000	37,613	36,247	[9]Consolidated.									101,860
....		25,600	26,000	26,000	52,098	43,076	54,300	35,700	87,613	49,852	29,455	29,439	73,115	532,248
....		[10]13,850	17,800	26,600	21,077	25,777	27,720	15,331	23,155	37,401	34,168	28,294	32,342	303,515
....		12,535	16,347	Closed.		[11]Partly dismantled.			In reserve.					28,882
....		21,500	14,455	24,730	49,931	57,553	55,352	70,050	48,361	38,159	50,418	34,674	40,396	505,579
....		11,200	[12]14,455	[12]24,832	Closed.		[Consolidated.							50,487
....		10,500	[12]14,455	[12]24,780				Closed; in reserve.						49,735
....		6,400	2,198	[13]Abandoned.										8,598
....		25,161	2,401	4,206	Closed.		[14]Abandoned.							31,768
....			7,000	4,089		Closed.		[15]Abandoned.						11,089
....						15,429	26,984	15,277		Closed; in reserve.				57,690
....									21,005	2,113	6,643	11,912	13,370	55,043
....									21,515	24,000	30,061	31,600	33,086	140,262
....									17,893	12,000	27,400	21,500	26,617	105,410
....										17,000	29,800	19,000	30,409	96,209
....										13,375	16,500	15,569	29,700	75,144
750	198,650	386,753	350,451	384,279	274,755	291,152	322,356	232,237	358,357	298,310	277,741	242,185	358,450	4,164,881
000	25,000	25,000	33,000	30,883	Closed.	35,848	30,413	33,631	35,676	35,890	41,011	45,383	63,935	493,070
500	19,000	30,000	31,000	31,077	31,859	37,188	30,038	34,632	39,115	37,849	42,306	46,775	60,797	515,636
200	30,000	33,221	30,400	37,100	31,640	34,750	30,999	33,434	38,314	34,117	39,962	43,566	62,597	514,622
....	15,886	27,764	23,990	30,363				Closed; in reserve.						98,003
....				3,995	Closed.		[17]17,394	12,007	20,004	[18]Sold; dismantled.				53,400
....								22,731	27,133	34,676	34,870	43,790	62,334	225,534
....								13,700	8,600	18,000	28,000	31,000	36,058	135,358
....									29,730	55,508	94,053	116,651	101,892	397,834
....									19,764	38,272	38,501	44,984	54,682	196,203
....												18,228	43,387	61,615
....												21,455	40,090	61,545
....													45,200	45,200
....													21,652	21,652
....													6,653	6,653
700	89,886	115,985	118,390	133,418	63,499	107,786	108,844	150,135	218,336	254,312	318,703	411,832	599,277	2,826,325
462	81,128	141,760	142,901	156,615	115,722	136,053	142,544	148,476	262,381	271,867	251,385	310,219	456,639	2,774,475
....		24,204	42,194	68,091	None.	76,998	78,663	59,494	92,866	52,057	60,826	61,795	69,998	687,186
765	42,451	50,494	28,655	58,997	20,741	31,665	34,033	36,188	34,767	32,532	56,442	52,115	63,775	663,273
750	198,650	386,753	350,451	384,279	274,755	291,152	322,356	232,237	358,357	298,310	277,741	242,185	358,450	4,164,881
700	89,886	115,985	118,390	133,418	63,499	107,786	108,844	150,135	218,336	254,312	318,703	411,832	599,277	2,826,325
677	412,115	719,196	682,591	801,400	474,717	643,654	686,440	626,530	966,707	909,078	965,097	1,078,146	1,548,139	11,116,140

shik River.
uk Bay.
fining Co., to form Hume-Aleutian Packing

[13] Machinery moved to Bering Sea Packing Co., Ugashik River.
[14] Moved to Arctic Packing Co., Naknek River.
[15] Machinery moved to Point Roberts Packing Co., Kvichak Bay.
[16] Experimental pack.
[17] Moved to new site on same river.
[18] Available property moved to Ugashik Fishing Station, Ugashik River.

[Cases = 48 one-pound or 96 half-pound tins. Tierces = 400 pounds net. Barrels =

Name of company and location of cannery.	Daily capacity, in cases.	Redfish.				Cohoes.				Humpbacks.		
		Number of cases packed.	Average number fish per case.	Packing.		Number of cases packed.	Average number fish per case.	Packing.		Number of cases packed.	Average number fish per case.	Beg
				Began.	Ceased.			Began.	Ceased.			
Arctic Packing Co. (A. P. A.), Nushagak Bay	1,600	38,363	13	June 16	July 23	1,132	11	July 18	July 24			
Alaska Packing Co. (A. P. A.), Nushagak Bay	1,600	38,538	13	June 21	July 25	1,321	11	July 22	....do...			
Bristol Bay Canning Co. (A. P. A.), Nushagak Bay	1,600	37,950	13	June 20	July 24	752	11	July 21	July 23			
Point Roberts Packing Co. (A. P. A.), Kvichak Bay	4,800	93,963	12	June 18	July 18							
Arctic Packing Co. (A. P. A.), Naknek River	1,600	34,845	12.5	June 14	July 16							
Naknek Packing Co., Naknek River	1,500	28,000	12	June 20	July 23							
Ugashik Fishing Station (A. P. A.), Ugashik River	1,600	38,501	13	June 19	July 21							
Chignik Bay Co. (A. P. A.), Chignik Lagoon	1,600	50,418	10.5	June 9	Aug. 9							
Pacific Steam Whaling Co., Anchorage Bay, Chignik	900	29,897	10.5	....do...	Aug. 12	79	10	Aug. 1	Aug. 15			
Hume Bros. & Hume, Anchorage Bay, Chignik	800	27,400	10.5	June 4	Aug. 10							
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak	1,000	34,168	13.5	....do...	Aug. 20							
Karluk Packing Co. (A. P. A.), Karluk	1,800	28,898	13	June 2	Sept. 24							
Alaska Improvement Co. (A. P. A.), Karluk	1,800	27,734	13	June 8	Sept. 17	1,721	8.5	Sept. 1	Sept. 17			
Hume-Aleutian Packing Co. (A. P. A.), Karluk	1,800	22,974	13	July 21	Sept. 9	1,424	8.5	Sept. 7	Sept. 9			
Uganuk Fishing Station (A. P. A.), Uganuk Bay	1,000	6,643	11	June 8	June 17							
Pacific Steam Whaling Co., Uyak Bay	900	29,800	12.5	May 25	Sept. 10							
Hume Bros. & Hume, Uyak Bay	900	16,500	12.5	June 4	Sept. 14							
Pacific Steam Whaling Co., Kenai	800	11,736	12.8	July 1	Aug. 20	3,075	8.5	July 21	Aug. 20			
Arctic Fishing Co. (A. P. A.), Kussilof River	1,500	28,810	13	May 26	Aug. 10	7,196	12	July 15	Aug. 10			
Pacific Packing Co. (A. P. A.), Odiak	1,500	17,541	10.5	May 10	Aug. 5					14,433	20	July
Pacific Steam Whaling Co., Orca	800	23,338	9.5	May 17	July 28					5,248	20	July
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor	1,600	34,851	11	July 6	Sept. 20	4,799	7.5	Aug. 16	Sept. 20			
Glacier Packing Co. (A. P. A.), Point Highfield	1,500	10,888	11	June 25	Aug. 5	12,653	7.5	July 5	Sept. 10	23,700	17	July
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring	2,800	16,416	11.5	June 22	Aug. 26	5,482	8.95	Aug. 17	....do...	37,445	18.58	July
Boston Fishing and Trading Co., Yes Bay	800	4,919	8.5	July 14	Sept. 6	160	7.5	Aug. 18	Sept. 15	5,473	15	July
Quadra Packing Co., Mink Arm, Boca de Quadra	600	10,000	11	July 15	Aug. 25	2,000	8	Aug. 12	Sept. 5	4,000	18	July
Metlakahtla Industrial Co., Metlakahtla	700	7,850	13.4	June 16	Sept. 3	1,047	7.93	Aug. 10	Sept. 13	2,774	19	July
Baranoff Packing Co., Redfish Bay	500	12,681	11	June 21	Aug. 28							
North Pacific Trading and Packing Co., Klawak	500	9,172	11.3	June 20	Aug. 23	3,654	6	Aug. 16	Sept. 29	3,481	20	July
Pacific Steam Whaling Co., Hunter Bay	1,600	10,147	11.5	June 22	Aug. 30	8,216	7.6	July 18	Sept. 13	12,845	14.5	July
Total		782,941				54,711				109,399		

Name of company and location of cannery.	Daily capacity in cases.	Redfish.				Cohoes.				Humpback		
		Number of cases packed.	Average number fish per case.	Packing—		Number of cases packed.	Average number fish per case.	Packing—		Number of cases packed.	Average number fish per case.	Be
				Began.	Ceased.			Began.	Ceased.			
Arctic Packing Co. (A. P. A.), Nushagak Bay	1,600	42,932	13	June 16	July 20							
Alaska Packing Co. (A. P. A.), Nushagak Bay	1,600	44,044	13	June 24	July 23	36						
Bristol Bay Canning Co. (A. P. A.), Nushagak Bay	1,600	41,562	13	June 20	July 18							
Pacific Steam Whaling Co., Nushagak Bay	1,600	25,978	13	June 26	July 14							
Alaska Fishermen's Packing Co., Nushagak Bay	1,600	21,165	12.5	June 25	July 25	290	12	July 24	July 25			
Point Roberts Packing Co. (A. P. A.), Kvichak Bay	4,800	116,385	12	June 18	July 23							
Arctic Packing Co. (A. P. A.), Naknek River	1,600	43,744	12.5	June 15	July 19							
Naknek Packing Co., Naknek River	1,500	31,000	12	June 22	July 24							
Ugashik Fishing Station (A. P. A.), Ugashik River	1,600	44,984	13	June 19	July 24							
Chignik Bay Co. (A. P. A.), Chignik Lagoon	1,600	33,562	10.5	June 10	Aug. 23	1,113	10.5	Aug. 9	Aug. 26			
Pacific Steam Whaling Co., Anchorage Bay, Chignik	900	31,600	10.5	June 7	Aug. 12							
Hume Bros. & Hume, Anchorage Bay, Chignik	800	21,245	10.5	June 8	Aug. 13	255	9	Aug. 12	Aug. 12			
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak	1,000	28,041	13.5	June 15	Aug. 30	253						
Karluk Packing Co. (A. P. A.), Karluk	1,800	31,143	13	June 1	Sept. 25							
Alaska Improvement Co. (A. P. A.), Karluk	1,800	27,786	13	June 12	Sept. 2	1,411	8.5	Aug. 31	Sept. 2			
Hume-Aleutian Packing Co. (A. P. A.), Karluk	1,800	17,366	13	July 24	Sept. 7	1,621	8.5	Aug. 29	Sept. 7			
Uganuk Fishing Station (A. P. A.), Uganuk Bay	1,000	11,912	11	June 7	July 20							
Pacific Steam Whaling Co., Uyak Bay	900	19,000	12.5	May 24	Sept. 10							
Hume Bros. & Hume, Uyak Bay	900	14,919	12.5	May 31	Sept. 1					650	21	Ju
Pacific Steam Whaling Co., Kenai	800	17,582	12.8	May 30	Aug. 12	3,311	9	July 27	Aug. 20			
Arctic Fishing Co. (A. P. A.), Kussilof River	1,500	23,342	13	May 26	Aug. 11	2,489	12	July 15	Aug. 12			
Pacific Packing Co. (A. P. A.), Odiak	1,500	25,279	11⅔	May 13	Aug. 12					5,864	25.5	Ju
Pacific Steam Whaling Co., Orca	800	24,932	11	May 10	July 24					4,316	20	Ju
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor	1,600	48,495	11	July 8	Aug. 31	562	7.5	Aug. 24	Aug. 30			
Glacier Packing Co. (A. P. A.), Point Highfield	1,500	10,081	12	June 25	Aug. 1	6,956	8	July 10	Sept. 3	30,993	18	Ju
Thlinket Packing Co., Gerard Point	800	2,750	11.5	July 6	Aug. 1	4,650	7.5	Aug. 1	Sept. 10	2,600	18	Ju
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring	1,800	19,218	11.76	June 18	Aug. 29	3,581	9.15	Aug. 22	Sept. 15	40,591	18.99	Ju
Boston Fishing and Trading Co., Yes Bay	800	7,965	8.6	July 11	Sept. 11	1,546	7.5	Aug. 29	Sept. 13	15,993	15	Ju
Quadra Packing Co., Mink Arm, Boca de Quadra	600	12,500	11	July 4	Aug. 25	2,500	7.5	Aug. 25	Sept. 20	21,000	20	Ju
Metlakahtla Industrial Co., Metlakahtla	700	6,373	13.4	July 1	Sept. 2	997	8	Aug. 8	Sept. 15	4,952	22	Ju
North Pacific Trading and Packing Co., Klawak	500	14,600	11	June 20	Aug. 24	2,000	6	Aug. 16	Sept. 18	2,500	20	Ju
Pacific Steam Whaling Co., Hunter Bay	1,600	12,770	12	June 14	Sept. 4	5,795	9	Aug. 17	Sept. 13	19,700	18.9	Ju
Total		864,254				39,102				149,159		

salmon—1898.

pounds net. Half-barrels = 100 pounds net. Casks = 800 pounds net.]

	King.				Dog.					
king. Ceased.	Number of cases packed.	Average number fish per case.	Packing. Began.	Packing. Ceased.	Number of cases packed.	Average number fish per case.	Packing. Began.	Packing. Ceased.	Total number of cases packed.	Salt packs of canning plants.
	1,388	3	June 16	June 29	128	13	June 20	June 29	41,011	
	2,265	3	June 6	June 30	182	13	June 22	June 24	42,306	900 barrels redfish.
	1,093	3	June 19	July 1	167	13	June 20	June 29	39,962	
	90	3	June 18	July 18					94,053	787 barrels and 362 half barrels redfish.
	25	5	....do...	June 29					34,870	907 barrels redfish.
									28,000	2,000 barrels redfish.
									38,501	277 barrels and 496 half barrels redfish.
									50,418	
					85	10	July 20	July 26	30,061	90 barrels humpback bellies.
									27,400	90 barrels and 4 half barrels redfish.
									34,168	59 barrels and 71 half barrels redfish.
									28,898	
									29,455	
									24,398	
									6,643	
									29,800	
									16,500	
	2,065	3	June 5	July 1					16,876	
	3,560	3	May 26	July 25					39,566	
Aug. 5	184	45	May 10	June 9					32,158	
July 31	82	4	May 17	June 15					28,668	
	19		Scattering in early part of season.						39,669	
Aug. 25	2,091	4	May 15	June 26					49,332	
Aug. 30									59,343	650 barrels redfish; 300 half barrels bellies (Hetta).
Aug. 31					4,622	6	July 24	Aug. 20	15,174	110 barrels cohoes.
Aug. 25									16,000	70 tierces full king; 12 barrels white king bellies.
....do...									11,671	
									12,681	
Aug. 16									16,307	250 cases clams; 225 cases clam juice.
Aug. 23									31,208	680 half barrels bellies (Nutqua).
	12,862				5,184				965,097	

salmon, 1899.

	King.				Dog.					
ecking— o. Ceased.	Number of cases packed.	Average number fish per case.	Packing— Began.	Packing— Ceased.	Number of cases packed.	Average number fish per case.	Packing— Began.	Packing— Ceased.	Total number of cases packed.	Salt packs of canning plants.
	2,229	3	June 13	June 26	222	13	June 20	June 24	45,383	
	2,097	3	....do...	June 24	598	13	June 22	June 26	46,775	1,695 barrels and 86 half barrels redfish.
	1,893	3	....do...	June 25	111	13	June 23	June 24	43,566	
	2,250	2.8	June 10	July 1					18,228	
									21,455	
	266	3	June 18	July 21					116,651	
	46	3	June 16	June 19					43,790	2,875 barrels and 1,000 half barrels redfish.
									31,000	300 barrels and 1,500 half barrels redfish.
									44,984	998 barrels and 990 half barrels redfish.
									34,674	
									31,600	60 barrels humpback bellies.
									21,500	
									28,294	38 barrels and 75 half barrels redfish.
	67	5	June 17	June 18					31,210	
	203	5	June 14	June 27					29,439	
									18,987	
									11,912	
									19,000	
									15,569	
Aug. 26	2,404	2.9	May 27	July 18					23,300	
	2,984	3	May 26	July 24					28,815	
Aug. 14	788	1	May 13	June 17					31,931	
Aug. 7	616	1	May 9	June 8					29,864	
	1,180	2.5	May 31	June 30					53,237	
Aug. 17	2,171	1	May 15	July 25					50,201	
Aug. 20	1,200	3	....do...	July 29					11,200	
Aug. 30									63,390	300 barrels redfish; 350 half barrels bellies (Hetta).
Sept. 8									25,504	
Aug. 30					1,000	7	July 28	Aug. 20	37,000	130 casks full king; 12 barrels white king bellies; 200 barrels full redfish; 1,500 barrels clean herring.
Aug. 26									12,322	
Aug. 20									19,100	
Sept. 12									38,265	900 half barrels full humpbacks.
	23,400				1,931				1,078,146	

Alaska pack of canned

[For salt output of canning com

Name of company and location of cannery.	Daily capacity in cases.	Redfish.				Cohoes.				Humpbacks.		
		Number of cases packed.	Average number fish per case.	Packing.		Number of cases packed.	Average number fish per case.	Packing.		Number of cases packed.	Average number fish per case.	Pa
				Began.	Ceased.			Began.	Ceased.			Began.
Arctic Packing Co. (A. P. A.), Nushagak Bay	2,400	57,230	13	June 23	July 23	1,254	10	July 22	July 23			
Alaska Packing Co. (A. P. A.), Nushagak Bay	2,400	56,228	13	June 25	July 24	332	10	July 21	July 24			
Bristol Bay Canning Co. (A. P. A.), Nushagak Bay	2,400	57,079	13	June 20	July 25	931	10	July 23	July 23			
Pacific Steam Whaling Co., Nushagak Bay	1,600	39,223	13	June 22	July 22							
Alaska Fishermen's Packing Co., Nushagak Bay	1,600	38,100	12.5	June 25	....do							
Point Roberts Packing Co. (A. P. A.), Kvichak Bay	4,800	99,578	12.5	June 23	July 25	297	10	July 20	July 25	1,676		July 1
Kvichak Packing Co. (A. P. A.), Kvichak Bay	2,400	45,200	12.5	June 28	Aug. 1							
Arctic Packing Co. (A. P. A.), Naknek River	2,400	61,816	12.5	June 18	July 28					449	20	July 2
Naknek Packing Co., Naknek River	1,500	35,675	12	June 23	July 25					352	22	July 2
Egegak Packing Co. (A. P. A.), Egegak River	1,600	21,652	12.5	July 1	July 28							
Ugashik Fishing Station (A. P. A.), Ugashik River	2,400	54,581	13	June 21	July 29							
Bristol Packing Co., Ugashik River	500	6,653	12	July 9	....do							
Chignik Bay Co. (A. P. A.), Chignik Lagoon	1,600	40,334	10.5	June 10	Aug. 12	62	10	Aug. 3	Aug. 12			
Pacific Steam Whaling Co., Anchorage Bay, Chignik	900	32,966	10.5	June 9	Aug. 6							
Hume Bros. & Hume, Anchorage Bay, Chignik	800	23,003	10.5	June 6	Aug. 19					13,614		July 2
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak	1,000	32,342	13.5	June 8	Aug. 13							
Karluk Packing Co. (A. P. A.), Karluk	1,800	77,558	13.6	June 9	Sept. 14	1,382	7.2	Aug. 25	Sept. 14			
Alaska Improvement Co. (A. P. A.), Karluk	1,800	69,712	13.9	June 4	Sept. 21	2,791	8	...do	Sept. 21			
Uganuk Fishing Station (A. P. A.), Uganuk Bay	1,000	13,370	12.8	June 9	July 17							
Pacific Steam Whaling Co., Uyak Bay	900	29,384	12.5	May 28	Aug. 25					1,025	21	July 2
Hume Bros. & Hume, Uyak Bay	900	27,636	12.5	June 5	Sept. 20					2,064	21	July
Alaska Salmon Association, Chuitna River	500	3,640	12	July 1	Aug. 9					5		{Latter son.
Pacific Steam Whaling Co., Kenai	800	20,924	13	June 1	Aug. 10	1,765	8.1	July 1	Aug. 10			
Arctic Fishing Co. (A. P. A.), Kussilof River	1,500	22,185	13	May 27	Aug. 12	5,427	12	July 16	Aug. 12			
Pacific Packing Co. (A. P. A.), Odiak	1,500	35,049	11.5	May 9	Aug. 4					3,888	22¼	July
Pacific Steam Whaling Co., Orca	800	28,501	12	May 7	July 22					1,718	28	July 2
Western Fisheries Co., Dundas Bay	300	6,130	12	June 28	Aug. 25	977	7.5	July 30	Sept. 20	1,866	18	July 1
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor	1,600	51,856	11	July 9	Sept. 1	513	7.5	Aug. 20	Sept. 1			
Chilkoot Packing Co., Chilkoot Inlet	300	13,948	8.3	June 30	Sept. 7	744	8	Sept. 7	Sept. 15			
Taku Packing Co., Taku Inlet	250	6,648	9	July 5	Aug. 12	3,227	7	Aug. 1	...do			
Taku Fishing Co., Port Snettisham	300	2,542	9	July 9	July 27	756	7	Sept. 1	Sept. 24	3,593	21	July 2
Icy Strait Packing Co., Petersburg, Wrangell Narrows	1,000	9,941	15	June 20	Aug. 20	1,500	7	Aug. 20	Oct. 10	10,000	20	July 1
Royer-Warnock Packing Co., Beecher Pass	20	480	12	July 1	Aug. 10	1,060	7.5	July 25	Sept. 1			
Glacier Packing Co. (A. P. A.), Point Highfield	1,500	10,848	10.1	June 18	....do ...	9,401	7.4	July 10	Sept. 18	36,432	15.8	July
Thlinket Packing Co., Gerard Point	800	3,965	11	June 28	Aug. 16	2,349	7.5	Aug. 2	Sept. 21	15,540	18	July 1
Fidalgo Island Canning Co., Ketchikan	1,000	6,399	11.5	July 10	Aug. 31	832	10	July 13	Sept. 8	19,685	19.25	July 1
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring	1,800	16,219	11.6	June 17	Aug. 29	3,825	9	Aug. 29	Sept. 18	47,114	19	July 1
Boston Fishing and Trading Co., Yes Bay	800	9,825	8.5	July 13	Sept. 7	2,306	7.5	Aug. 20	Sept. 27	20,051	15	July 1
Quadra Packing Co., Mink Arm, Boca de Quadra	800	6,000	10.7	July 14	Aug. 25	600	7.5	Aug. 25	Sept. 20	6,000	20	July 1
Metlakahtla Industrial Co., Metlakahtla	700	6,930	13.7	June 20	Sept. 5	610	8	July 27	Sept. 12	9,690	19.9	July 1
North Pacific Trading and Packing Co., Klawak	800	8,228	14.3	June 17	Aug. 25	3,973	8	Aug. 17	Sept. 25	15,551	17	July 1
Pacific Steam Whaling Co., Hunter Bay	1,600	7,828	12.8	June 18	Aug. 10	4,070	9	July 31	Sept. 10	31,709	18.6	....do
Total		1,197,406				50,984				232,022		

[1] Humpbacks and dog mixed—under "pink" label.

[2] R

Salmon, 1900.

[...nies, see page 313.]

...king.	King.				Dog.				Total number of cases packed.
	Number of cases packed.	Average number fish per case.	Packing.		Number of cases packed.	Average number fish per case.	Packing.		
Ceased.			Began.	Ceased.			Began.	Ceased.	
.....	3,530	3	June 15	June 25	1,921	13	June 19	June 27	63,935
.....	2,543	3	June 17	....do...	1,694	13	....do...	....do...	60,797
.....	2,256	3	....do...	June 28	2,331	13	June 23	....do...	62,597
.....	2,291	3.6	June 12	July 22	1,873	13	June 20	July 1	43,387
.....	1,990	3	June 15	....do...	.....	.....	.....	.....	40,090
July 25	341	3	June 23	July 25	.....	.....	.....	.....	101,892
.....	.....	.....	.....	.....	.....	.....	.....	.....	45,200
July 25	69	3	June 18	June 24	.....	.....	.....	.....	62,334
July 28	31	4.8	Scattering latter part of season.		.....	.....	.....	.....	36,058
.....	.....	.....	.....	.....	.....	.....	.....	.....	21,652
.....	101	3	June 18	June 29	.....	.....	.....	.....	54,682
.....	.....	.....	.....	.....	.....	.....	.....	.....	6,653
.....	.....	.....	.....	.....	.....	.....	.....	.....	40,396
.....	.....	.....	.....	.....	120	10	July 20	July 28	33,086
Aug. 19	.....	.....	.....	.....	.....	.....	.....	.....	26,617
.....	.....	.....	.....	.....	.....	.....	.....	.....	32,342
.....	475	5	June 9	June 24	.....	.....	.....	.....	79,415
.....	612	4.9	June 5	June 28	.....	.....	.....	.....	73,115
.....	.....	.....	.....	.....	.....	.....	.....	.....	13,370
Aug. 26	.....	.....	.....	.....	.....	.....	.....	.....	30,409
Sept. 20	.....	.....	.....	.....	.....	.....	.....	.....	29,700
rt of sea-	[2] 326 [3] 922	3.5	June 10	July 2	12	.....	Latter part of season.		4,905
.....	2,400	3.6	May 29	July 10	.....	.....	.....	.....	25,089
.....	6,169	3	May 27	July 22	.....	.....	.....	.....	33,781
Aug. 2	473	4½	May 9	June 12	.....	.....	.....	.....	39,410
July 24	369	4.2	May 7	June 7	.....	.....	.....	.....	30,588
Aug. 10	60	4.5	Sept. 1	Sept. 30	4,760	6.5	July 15	Sept. 20	13,793
.....	3,252	3.5	May 29	June 30	.....	.....	.....	.....	55,601
.....	.....	.....	.....	.....	158	8	Sept. 16	Sept. 25	14,850
.....	[2] 3,150 [4] 454 [3] 771	2.7	May 17	June 26	2,472	6.5	Aug. 15	....do...	16,722
Aug. 16	[2] 454 [3] 97	3	June 1	June 20	2,016	7	July 9	Sept. 24	9,458
Sept. 15	.....	.....	.....	.....	8,500	8.5	July 15	Oct. 30	29,941
.....	.....	.....	.....	.....	20	7.8	Scattering during August.		1,560
Aug. 22	1,837	3.8	May 15	July 1	.....	.....	.....	.....	58,518
Aug. 31	2,049	3	May 14	June 28	1,737	.....	Aug. 1	Sept. 15	25,640
Sept. 8	.....	.....	.....	.....	340	8.5	Aug. 24	Sept. 8	27,256
Sept. 6	.....	.....	.....	.....	.....	.....	.....	.....	67,158
Sept. 18	713	2.5	June 25	July 10	728	6	July 10	Sept. 27	33,623
Aug. 31	.....	.....	.....	.....	1,000	7	July 17	Aug. 31	13,600
Sept. 4	.....	.....	.....	.....	330	8.5	Aug. 25	Sept. 10	17,560
Aug. 27	.....	.....	.....	.....	.....	.....	.....	.....	27,752
Aug. 28	.....	.....	.....	.....	.....	.....	.....	.....	43,607
.....	37,715	.....	.....	.....	30,012	.....	.....	.....	1,548,139

[3] White. [4] Pink.

The following recapitulation shows the total packs for 1898, 1899, and 1900, and the percentage the different species contribute to each pack:

Species.	Cases.	Per cent.
1898.		
Redfish	782,941	81.12
Cohoes	54,711	5.67
Humpbacks	109,399	11.34
King	12,862	1.33
Dog	5,184	.54
Total	965,097	.....
1899.		
Redfish	864,254	80.16
Cohoes	39,402	3.65
Humpbacks	149,159	13.84
King	23,400	2.17
Dog	1,931	.18
Total	1,078,146	.....
1900.		
Redfish	1,197,406	77.34
Cohoes	50,984	3.29
Humpbacks	232,022	14.99
King	37,715	2.44
Dog	30,012	1.94
Total	1,548,139	.....

Salt salmon pack of Alaska, 1900.

Name of concern and location of saltery.	King, whole.	King, bellies.	Redfish, whole.	
	Barrels.	*Barrels.*	*Barrels.*	*Half bbls.*
Alaska Packing Co. (A. P. A.), Nushagak Bay			1,420	698
Pacific Steam Whaling Co., Nushagak Bay			415	
Alaska Fishermen's Packing Co., Nushagak Bay			465	105
C. E. Whitney & Co., Nushagak Bay	536		7,186	
Point Roberts Packing Co. (A. P. A.), Kvichak Bay			92	115
Arctic Packing Co. (A. P. A.), Naknek River			1,356	1,141
Naknek Packing Co. Naknek River	22		1,150	
Egegak Packing Co. (A. P. A.), Egegak River			852	1,513
Ugashik Fishing Station (A. P. A.), Ugashik River			603	606
Bristol Packing Co., Ugashik River			1,150	
Hume Bros. and Hume, Uyak Bay			25	
Alaska Salmon Association, Chuitna River			44	
Perry Hinkle, Port Althorp, Surge Bay			800	
Icy Strait Packing Co., Bartlett Bay, Icy Strait			530	
Icy Strait Packing Co., Taku Inlet	400	12		
Perry Hinkle, Freshwater Bay and Basket Bay			900	
Alaska Oil and Guano Co., Killisnoo	5		210	8
Great Northern Fish Co., Redfish Bay, Baranof Island			850	
Jack Mantle, Point Ellis, Kuiu Island			220	
Zip Moon, Point Barrie			200	
Icy Strait Packing Co., Shipley Bay			200	
Royer-Warnock Packing Co., Beecher Pass			19	
Great Northern Fish Co., Union Bay			100	
John E. Rice, Karta Bay			75	25
Alaska Packers Association, Hetta Inlet			179	
Total	963	12	19,041	4,211

Name of concern and location of saltery.	Cohoes, whole.		Humpbacks, whole.	Humpbacks, bellies.		Dog, whole.	Remarks.
	Barrels.	*Half bbls.*	*Barrels.*	*Barrels.*	*Half bbls.*	*Barrels.*	
Ugashik Fishing Station (A. P. A.) Ugashik River.	10						[1] Bellies.
Pacific Steam Whaling Co., Anchorage Bay, Chignik.				69			
Alaska Salmon Association, Chuitna River			3				
Icy Strait Packing Co., Bartlett Bay, Icy Strait.	120						
Alaska Oil and Guano Co., Killisnoo					523		Also 100 barrels and 185 half barrels herring.
Zip Moon, Point Barrie			15				
Finn & Young, Shakan			[2]500				[2] Includes some redfish and cohoes.
Fred. Brockman, Sarcar					225		
Icy Strait Packing Co., hulk *Blanche*, Wrangell Narrows.	100						Also 1,000 barrels herring.
Pacific Coast and Norway Packing Co., Wrangell Narrows.	8						Also 250 barrels herring.
Tom McCauley, Whale Passage					900		
John Frey, Zimovia Strait			200		300		
Great Northern Fish Co., Union Bay	[3]400		4,500				[3] Includes some bright-fleshed dog salmon packed as cohoes.
Robert Bell, Thorne Bay	140			280	500		
Great Northern Fish Co., Karta Bay						[4]1,200	[4] Dry salted.
John E. Rice, Karta Bay	75	50				[5]1,207	[5] Dry salted.
Alex. Miller, Cholmondeley Sound			700		800		
Z. Doty, Mink Arm, Boca de Quadra						[6]150	[6] Dry salted; estimated.
Alaska Packers Association, Hetta Inlet				61	84		
Craig Miller, Copper Mountain Bay			400		450		
Banter & West, Sukkwan Inlet							Sold fresh to canneries; salted few for local use.
Total	853	50	6,318	410	3,782	2,557	

RECAPITULATION.

Species.	Description.	Barrels.	Half barrels.
King	Whole	963	
	Bellies	12	
Redfish	Whole	19,041	4,211
	Whole	843	50
Cohoes	Bellies	10	
	Whole	6,318	
Humpbacks	Bellies	410	3,782
Dog	Whole	2,557	
	Total	30,154	8,043
	Half barrels reduced at 2 for 1 to barrels	4,021	
	Grand total	34,175	

Vessels employed, 1898.

Name of company and location of cannery.	Steam vessels.					
	Name.	Class.	Tons.	Crew.	Value.	Ownership.
Arctic Packing Co. (A. P. A.), Alaska Packing Co. (A. P. A.), Nushagak Bristol Bay Canning Co. (A. P. A.), Bay.	Polar Bear	Steamer	28	5	$12,000	Owned.
	Amy S	Launch	5	2	3,000	Do.
	Tyone	do	5	2	4,500	Do.
	Corrinne	do	5	2	1,500	Do.
Point Roberts Packing Co. (A. P. A)., Kvichak Bay.	President	Steamer	238	9	40,000	Do.
	Herbert	Launch	5	2	4,000	Do.
	Northern Light	do	4	2	3,000	Do.
Arctic Packing Co. (A. P. A.), Naknek River.	Thistle[1]	Steamer	56	5	25,000	Do.
	Ralph L	Launch	5	2	4,500	Do.
Naknek Packing Co., Naknek River	Amelia	Gas launch	5	2	1,200	Do.
Ugashik Fishing Station (A. P. A.), Ugashik River.	Cathie K	Launch	3	2	2,500	Do.
Chignik Bay Co. (A. P. A.), Chignik Lagoon.	Afognak	Steamer	37	5	16,000	Do.
	Baby Ruth	Stern-wheel	10	4	4,500	Do.
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	Esquimaux	Launch	5	2	2,500	Do.
Hume Bros. & Hume, Anchorage Bay, Chignik.	Ethel and Marian	do	6	3	2,800	Do.
	Florence Hume	do	5	2	3,000	Do.
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.	Hattie Gage	Steamer	42	5	17,000	Do.
Karluk Packing Co. (A. P. A.), Karluk.	Kadiak	do	58	9	20,000	Do.
Alaska Improvement Co. (A. P. A.), Karluk.	Gertie Story	do	36	7	10,000	Do.
	Delphine	Launch	5	2	2,500	Do.
Hume-Aleutian Packing Co. (A. P. A.), Karluk.	Aurora	do	5	2	3,500	Do.
	Ida	do	5	2	2,700	Do.
Uganuk Fishing Station (A. P. A.), Uganuk Bay.	Julia M	do	5	2	2,000	Do.
Pacific Steam Whaling Co., Uyak Bay.	Golden Gate	Steamer	59	8	25,000	Do.
	Kenai	Launch	5	2	7,000	Do.
Hume Bros. & Hume, Uyak Bay	Equator	Steamer	42	7	10,000	Do.
	Herbert Hume	Launch	5	2	3,500	Do.
Pacific Steam Whaling Co., Kenai	Salmo	Steamer	28	6	10,000	Do.
	Anita[2]	Launch	5	2	1,000	Do.
Arctic Fishing Co. (A. P. A.), Kussilof River.	Jennie	Steamer	69	6	26,000	Do.
	Arthur	Launch	5	2	2,000	Do.
Pacific Packing Co. (A. P. A.), Odiak.	S. B. Matthews	Stern-wheel	164	6	14,000	Do.
	Pacific	Steamer	31	6	14,000	Do.
	Susanna	Stern-wheel	18	4	8,000	Do.
Pacific Steam Whaling Co., Orca	Wild Cat	do	104	4	10,000	Do.
	Thlinket	do	90	4	10,000	Do.
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	Elsie	Steamer	37	4	16,000	Do.
	Lillian	do	19	3	9,000	Do.
Glacier Packing Co. (A. P. A.), Point Highfield.	Ella Rohlffs	do	36	5	14,000	Do.
	Aleut	do	19	5	10,000	Do.
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.	Novelty	do	33	5	12,000	Do.
	Arctic	do	21	5	8,000	Do.
Boston Fishing and Trading Co., Yes Bay.	Rosie	Launch	8	2	2,000	Do.
Quadra Packing Co., Mink Arm, Boca de Quadra.	White Wings	Steamer	34	6	7,000	Do.
	Annie M. Nixon	do	18	6	6,000	Do.
Metlakahtla Industrial Co., Metlakahtla.	Herald	do	17	5	7,000	Do.
	Marie G. Haaven	do	12	5	4,000	Do.
Baranoff Packing Co., Redfish Bay.	Wigwam	do	24	5	10,000	Do.
North Pacific Trading and Packing Co., Klawak.	Klawack	do	10	4	5,000	Do.
	Cora	Launch	5	2	1,500	Do.
Pacific Steam Whaling Co., Hunter Bay.	Alice	Steamer	19	5	10,000	Do.

[1] Also attended Ugashik Station.

[2] Lost, fall of 1898.

Vessels employed, 1898—Continued.

Name of company and location of cannery.	Sail vessels.					
	Name.	Rig.	Tons.	Crew.	Value.	Ownership.
Arctic Packing Co. (A. P. A.), Nushagak Bay.	Oriental	Ship	1,550	Fishermen	$40,000	Chartered.
Alaska Packing Co. (A. P. A.), Nushagak Bay.	Indiana	....do	1,413	Fishermen	40,000	Owned.
Bristol Bay Canning Co. (A. P. A.), Nushagak Bay.	Willie R. Hume	4-mast barkentine.	589	Fishermen	25,000	Chartered.
Point Roberts Packing Co. (A. P. A.), Kvichak Bay.	W. H. Macy	Ship	2,038	Fishermen	50,000	Do.
	Sterling[1]	....do	1,637	Fishermen	30,000	Owned.
	Bohemia	....do	1,528	Fishermen	35,000	Do.
	Prosper	3-mast schooner	229	Fishermen	15,000	Do.
Arctic Packing Co. (A. P. A.), Naknek River.	Merom	Bark	1,134	Fishermen	16,000	Do.
	Antelope	Schooner	117	Fishermen	7,000	Chartered.
Naknek Packing Co., Naknek River	B. P. Cheney	Bark	1,200	Fishermen	15,000	Owned.
Ugashik Fishing Station (A. P. A.), Ugashik River.	Nicolas Thayer	....do	555	Fishermen	12,000	Do.
	Will W. Case	....do	554	Fishermen	12,000	Do.
Chignik Bay Co. (A. P. A.), Chignik Lagoon.	Llewellyn J. Morse	Ship	1,271	Fishermen	35,000	Do.
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	(Transports by calling vessel of company.)					
Hume Bros. & Hume, Anchorage Bay, Chignik.	Ferris S. Thompson	Bark	480	11	9,000	Owned.
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.	Coryphene	....do	733	Fishermen	10,000	Chartered.
Karluk Packing Co. (A. P. A.), Karluk.						
Alaska Improvement Co. (A. P. A.), Karluk.	St. Nicholas	Ship	1,687	Fishermen	40,000	Do.
Hume-Aleutian Packing Co. (A. P. A.), Karluk.	Santa Clara	....do	1,453	Fishermen	35,000	Owned.
Uganuk Fishing Station (A. P. A.), Uganuk Bay.						
Pacific Steam Whaling Co., Uyak Bay.	(Transports by calling vessel of company.)					
Hume Bros. & Hume, Uyak Bay	Harvester[2]	Bark	716	12	9,000	Owned.
Pacific Steam Whaling Co., Kenai	(Transports by calling vessel of company.)					
Arctic Fishing Co. (A. P. A.), Kussilof River.	Centennial	Ship	1,138	Fishermen	20,000	Do.
Pacific Packing Co. (A. P. A.), Odiak.	Electra	Bark	939	Fishermen	12,000	Do.
Pacific Steam Whaling Co., Orca	America	Ship	1,908	Fishermen	40,000	Chartered.
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	Invincible	....do	1,393	Fishermen	25,000	Do.
Glacier Packing Co. (A. P. A.), Point Highfield.	George Skolfield	....do	1,275	Fishermen	20,000	Owned.
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.	Hecla	....do	1,435	Fishermen	25,000	Chartered.
Boston Fishing and Trading Co., Yes Bay.	(Transports by regular line of steamers.)					
Quadra Packing Co., Mink Arm, Boca de Quadra.	(Transports by regular line of steamers.)					
Metlakahtla Industrial Co., Metlakahtla.	(Transports by regular line of steamers.)					
Baranoff Packing Co., Redfish Bay.	(Transports by regular line of steamers.)					
North Pacific Trading and Packing Co., Klawak.	(Transports by special sail charter.)					
Pacific Steam Whaling Co., Hunter Bay.	(Transports by calling vessel of company.)					

[1] Lost, May, 1898.

[2] Also attended Chignik.

RECAPITULATION.

	Number.	Net tonnage.	Value.
Steam	51	1,515	$449,700
Sail	24	26,971	577,000
Total	75	28,486	1,026,700

Vessels employed, 1899.

Name of company and location of cannery.	Steam vessels.					
	Name.	Class.	Tons.	Crew.	Value.	Ownership.
Arctic Packing Co. (A. P. A.), Alaska Packing Co. Nushagak Bristol Bay Canning Co. Bay.	Polar Bear	Steamer	28	5	$12,000	Owned.
	Wigwam	do	23	3	10,000	Do.
	Amy S	Launch	5	2	4,000	Do.
	Tyone	do	5	2	5,000	Do.
	Corrinne	do	5	2	1,500	Do.
Pacific Steam Whaling Co., Nushagak Bay.	Jeanie	Steamer	862	12	75,000	Do.
	Rattler	Launch	5	2	4,500	Do.
Alaska Fishermen's Packing Co., Nushagak Bay.	North Star	Steamer	34	4	15,000	Do.
Point Roberts Packing Co. (A.P.A.), Kvichak Bay.	President	do	238	9	40,000	Do.
	Herbert	Launch	5	2	4,000	Do.
	Northern Light	do	4	2	3,000	Do.
Arctic Packing Co. (A. P. A.), Naknek River.	Thistle[1]	Steamer	56	5	25,000	Do.
	Ralph L	Launch	5	2	4,500	Do.
Naknek Packing Co., Naknek River.	Amelia	Gas launch	5	2	1,800	Do.
Ugashik Fishing Station (A. P. A.), Ugashik River.	Collis	Launch	5	2	7,000	Do.
	Cathie K	do	3	2	2,500	Do.
Chignik Bay Co. (A. P. A.), Chignik Lagoon.	Afognak	Steamer	37	5	17,000	Do.
	Baby Ruth	Stern-wheel	10	4	4,500	Do.
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	C. C. Cherry	Steamer	37	6	15,000	Do.
	Esquimaux	Launch	5	2	2,500	Do.
Hume Bros. & Hume, Anchorage Bay, Chignik.	Ethel and Marian	do	6	3	2,800	Do.
	Florence Hume	Launch	5	2	3,000	Do.
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.	Hattie Gage	Steamer	42	5	17,000	Do.
Karluk Packing Co. (A. P. A.), Karluk.	Kadiak	do	58	9	20,000	Do.
Alaska Improvement Co. (A.P.A.), Karluk.	Gertie Story	do	36	7	11,000	Do.
	Karluk	Launch	8	2	8,000	Do.
Hume-Aleutian Packing Co. (A. P. A.), Karluk.	Delphine	do	5	2	2,500	Do.
	Aurora	do	5	2	3,000	Do.
Uganuk Fishing Station (A. P. A.), Uganuk Bay.	Ida	do	5	2	2,700	Do.
Pacific Steam Whaling Co., Uyak Bay.	Wallowa	Steamer	92	10	12,500	Chartered.
	Kenai	Launch	5	2	7,000	Owned.
Hume Bros. & Hume., Uyak Bay	Equator	Steamer	42	7	11,000	Do.
	Francis Cutting	do	59	8	10,000	Do.
	Herbert Hume	Launch	5	2	3,500	Do.
Pacific Steam Whaling Co., Kenai.	Duxbury	Gasoline	30	5	10,000	Do.
	Salmo	Steamer	28	6	10,000	Do.
Arctic Fishing Co. (A. P. A.), Kussilof River.	Jennie	do	69	6	28,000	Do.
	Arthur	Launch	5	2	1,800	Do.
Pacific Packing Co. (A. P. A.), Odiak.	S. B. Matthews	Stern-wheel	164	6	14,000	Do.
	Pacific	Steamer	31	6	14,000	Do.
	Susanna	Stern-wheel	18	4	8,000	Do.
Pacific Steam Whaling Co., Orca	Wild Cat	do	104	4	10,000	Do.
	Thlinket	do	90	4	10,000	Do.
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	Elsie	Steamer	37	4	16,000	Do.
	Lillian	do	19	3	9,000	Do.
Glacier Packing Co. (A. P. A.), Point Highfield.	Ella Rohlffs	do	36	5	14,000	Do.
	Aleut	do	19	5	10,000	Do.
Thlinket Packing Co., Point Gerard.	Perhaps	Launch	6	2	1,500	Do.
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.	Novelty	Steamer	33	5	12,000	Do.
	Arctic	do	21	5	6,000	Do.
Boston Fishing and Trading Co., Yes Bay.	Rosie	Launch	8	2	2,000	Do.
Quadra Packing Co., Mink Arm, Boca de Quadra.	Gypsy Queen	Stern-wheel	58	None.	6,000	Do.
	White Wings	Steamer	34	6	7,000	Do.
	Annie M. Nixon	do	18	6	6,000	Do.
Metlakahtla Industrial Co., Metlakahtla.	Herald	do	17	5	8,000	Do.
	Marie G. Haaven	do	12	5	4,000	Do.
North Pacific Trading and Packing Co., Klawak.	Klawack	do	10	4	6,000	Do.
	Cora	Launch	5	2	1,500	Do.
Pacific Steam Whaling Co., Hunter Bay.	Golden Gate	Steamer	59	9	25,000	Do.
	Alice	do	19	5	11,000	Do.

[1] Also attended Uganuk.

Vessels employed, 1899—Continued.

Name of company and location of cannery.	Sail vessels.					
	Name.	Rig.	Tons.	Crews.	Value.	Ownership.
Arctic Packing Co. (A. P. A.), Alaska Packing Co. Nushagak, Bristol Bay Canning Co. Bay.	Oriental	Ship	1,550	Fishermen.	$50,000	Chartered.
	Indiana[1]	do	1,413	do	45,000	Owned.
	Invincible	do	1,393	do	25,000	Chartered.
	Willie R. Hume	4-mast barkentine	589	do	25,000	Do.
Pacific Steam Whaling Co., Nushagak Bay.	R. W. Bartlett	3-mast schooner	473	do	20,000	Do.
Alaska Fishermen's Packing Co., Nushagak Bay.	Harry Morse	Bark	1,241	do	20,000	Do.
Point Roberts Packing Co. (A.P.A.), Kvichak Bay.	Bohemia	Ship	1,528	do	45,000	Owned.
	Prosper	3-mast schooner	229	do	15,000	Do.
Arctic Packing Co. (A. P. A.), Naknek River.	Merom	Bark	1,134	do	18,000	Do.
Naknek Packing Co., Naknek River.	B. P. Cheney	do	1,200	do	18,000	Do.
Ugashik Fishing Station (A. P. A.) Ugashik River.	Coryphene	do	733	do	15,000	Chartered.
	Nicolas Thayer	do	555	do	12,000	Owned.
Chignik Bay Co. (A. P. A.), Chignik Lagoon.	Llewellyn J. Morse	Ship	1,271	do	35,000	Do.
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	(Transports by calling vessel of company.)					
Hume Bros. & Hume, Anchorage Bay, Chignik.	Ferris S. Thompson	Bark	480	11	10,000	Owned.
	Maid of Orleans	Schooner	171	8	7,000	Do.
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.	Electra	Bark	939	Fishermen.	12,000	Do.
Karluk Packing Co. (A. P. A.), Karluk.						
Alaska Improvement Co. (A.P.A.), Karluk.	St. Nicholas	Ship	1,687	do	40,000	Chartered.
Hume-Aleutian Packing Co. (A. P. A.), Karluk.	Santa Clara	do	1,453	do	35,000	Owned.
Uganuk Fishing Station (A. P. A.), Uganuk Bay.						
Pacific Steam Whaling Co., Uyak Bay.	(Transports by calling vessel of company.)					
Hume Bros. & Hume, Uyak Bay	Harvester	Bark	716	12	10,000	Owned.
Pacific Steam Whaling Co., Kenai.	(Transports by calling vessel of company.)					
Arctic Fishing Co. (A. P. A.), Kussilof River.	Centennial	Ship	1,138	Fishermen.	25,000	Owned.
Pacific Packing Co. (A. P. A.), Odiak.	Charles B. Kenney	Bark	1,014	do	25,000	Chartered.
Pacific Steam Whaling Co., Orca	America	Ship	1,908	do	50,000	Do.
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	Two Brothers	do	1,263	do	35,000	Owned.
Glacier Packing Co. (A. P. A.), Point Highfield.	George Skolfield	do	1,275	do	20,000	Do.
Thlinket Packing Co., Point Gerard.	(Transports by regular line of steamers.)					
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.	Sintram	Ship	1,495	Fishermen.	50,000	Chartered.
Boston Fishing and Trading Co., Yes Bay.	(Transports by regular line of steamers.)					
Quadra Packing Co., Mink Arm, Boca de Quadra.	Blanche	Schooner, hulk	107	Fishermen.	4,500	Owned.
	Elliott	Barge	43	do	1,000	Do.
Metlakahtla Industrial Co., Metlakahtla.	(Transports by regular line of steamers.)					
North Pacific Trading and Packing Co., Klawak.	(Transports by special sail charter.)					
Pacific Steam Whaling Co., Hunter Bay.	(Transports by calling vessel of company.)					

[1] Also called at Karluk.

RECAPITULATION.

	No.	Net tonnage.	Value.
Steam	60	2,700	$618,600
Sail	27	26,998	667,500
Total	87	29,698	1,286,100

Vessels employed, 1900.

Name of company and location of cannery.	Steam vessels.					
	Name.	Class.	Tons.	Crew.	Value.	Ownership.
Arctic Packing Co.	Polar Bear	Steamer	28	5	$12,000	Owned.
Alaska Packing Co. (A. P. A.) Nushagak Bay.	Queen	do	18	3	10,000	Do.
Bristol Bay Canning Co.	Amy S	Launch	5	2	4,000	Do.
	Tyone	do	5	2	6,000	Do.
Pacific Steam Whaling Co., Nushagak Bay	Rattler	do	5	2	4,500	Do.
Alaska Fishermen's Packing Co., Nushagak Bay.	North Star	Steamer	34	4	15,000	Do.
Point Roberts Packing Co. (A. P. A.) Kvichak Bay.	Kvichak	do	610	13	200,000	Do.
Kvichak Packing Co.	Sayak	Stern-wheel	90	4	8,000	Do.
	Lillian	Steamer	19	3	9,000	Do.
	Herbert	Launch	5	2	4,000	Do.
Arctic Packing Co. (A. P. A.), Naknek River.	President[1]	Steamer	238	9	40,000	Do.
	Ralph L	Launch	5	2	4,500	Do.
	Northern Light	do	4	2	3,000	Do.
Naknek Packing Co., Naknek River	Fram	Steamer	12	3	8,000	Do.
Egegak Packing Co. (A. P. A.), Egegak River.	Llewellyn	Launch	5	None.	1,000	Do.
	Corrinne	do	5	2	2,000	Do.
Ugashik Fishing Station (A. P. A.), Ugashik River.	Thistle	Steamer	56	5	25,000	Do.
	Collis	Launch	5	2	7,000	Do.
	Cathie K	do	3	2	2,500	Do.
Bristol Packing Co., Ugashik River	Amelia	Gasoline launch	5	2	2,000	Do.
Chignik Bay Co. (A. P. A), Chignik Lagoon	Afognak	Steamer	37	5	18,000	Do.
	Baby Ruth	Stern-wheel	10	4	5,000	Do.
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	C. C. Cherry	Steamer	37	6	15,000	Do.
	Esquimaux	Launch	5	2	2,500	Do.
Hume Bros. & Hume, Anchorage Bay, Chignik.	Ethel and Marian	do	6	3	2,880	Do.
	Florence Hume	do	5	2	3,200	Do.
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.	Hattie Gage	Steamer	42	5	17,000	Do.
	Aurora	Launch	5	None.	2,500	Do.
	Gertie Story	Steamer	36	7	12,000	Do.
Karluk Packing Co. (A. P. A.), Karluk	Kadiak	do	58	9	20,000	Do.
Alaska Improvement Co. (A. P. A), Karluk	Karluk	Launch	8	2	10,000	Do.
Uganuk Fishing Station (A. P. A.), Uganuk Bay.	Uganuk	do	8	2	10,000	Do.
	Ida	do	5	2	2,700	Do.
	Delphine	do	5	2	2,500	Do.
Pacific Steam Whaling Co., Uyak Bay	Shelikoff	Steamer	101	10	36,000	Do.
	Kenai	Launch	5	2	7,000	Do.
Hume Bros. & Hume, Uyak Bay	Francis Cutting	Steamer	59	8	10,000	Do.
	Equator	do	42	7	12,000	Do.
	Herbert Hume	Launch	5	2	3,500	Do.
Alaska Salmon Association, Chuitna River	King Fisher	do	7	3	5,500	Do.
Pacific Steam Whaling Co., Kenai	Duxbury	Gasoline vessel	30	5	10,000	Do.
	Salmo	Steamer	28	6	10,000	Do.
	Jennie	do	69	6	30,000	Do.
Arctic Fishing Co. (A. P. A.), Kussilof River.	Reporter	do	26	3	10,000	Do.
	Arthur	Launch	5	2	1,800	Do.
Pacific Packing Co. (A. P. A.), Odiak	S. B. Matthews	Stern-wheel	164	6	14,000	Do.
	Pacific	Steamer	31	6	15,000	Do.
	Susanna	Stern-wheel	18	4	8,000	Do.
Pacific Steam Whaling Co., Orca	Wild Cat	do	104	4	10,000	Do.
	Thlinket	do	90	4	10,000	Do.
Western Fisheries Co., Dundas Bay	Beaver	Steamer	19	5	5,500	Do.
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	Favorite	Launch	7	3	2,000	Chartered.
	Elsie	Steamer	37	4	16,000	Owned.
Chilkoot Packing Co., Chilkoot Inlet	Estella	do	20	3	3,500	Do.
Taku Packing Co., Taku Inlet	J. R. Roberts	Launch	9	2	3,000	Chartered.
Taku Fishing Co., Port Snettisham	Fawn	do	5	2	1,000	Owned.
	N. & S	Steamer	10	2	1,800	Do.
	Pescadero	Launch	4	1	600	Do.
Icy Strait Packing Co., Petersburg, Wrangell Narrows.	Gypsy Queen	Stern-wheel	58	None.	6,000	Do.
	White Wings	Steamer	34	6	7,000	Do.
	Annie M. Nixon	do	18	6	6,000	Do.
Royer-Warnock Packing Co., Beecher Pass	Ro-Wa	Gasoline launch	4	2	800	Do.
Glacier Packing Co. (A.P.A.), Point Highfield.	Ella Rohlffs	Steamer	36	5	15,000	Do.
	Aleut	do	19	5	10,000	Do.
Thlinket Packing Co., Gerard Point	Baranoff	do	10	5	5,000	Chartered.
	Perhaps	Launch	6	2	1,500	Owned.
Fidalgo Island Canning Co., Ketchikan	Delta	Steamer	59	6	6,000	Chartered.
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.	Novelty	do	33	5	12,000	Owned.
	Arctic	do	21	5	4,000	Do.
Boston Fishing and Trading Co., Yes Bay	Rosie	Launch	8	2	2,500	Do.
Quadra Packing Co., Mink Arm, Boca de Quadra.	Slowly	do	5	2	1,000	Chartered.
Metlakahtla Industrial Co., Metlakahtla	Herald	Steamer	17	5	9,000	Owned.
	Marie G. Haaven	do	12	5	5,000	Do.
North Pacific Trading and Packing Co., Klawak.	Klawack	do	10	4	7,000	Do.
	Cora	Launch	5	2	1,500	Do.
Pacific Steam Whaling Co., Hunter Bay	Golden Gate	Steamer	59	9	25,000	Do.
	Alice	do	19	5	12,000	Do.
	Alphonso XIII	Gasoline launch	5	2	3,000	Do.

[1] Also attended Egegak.

Vessels employed, 1900—Continued.

Name of company and location of cannery.	Sail vessels.					
	Name.	Rig.	Tons.	Crew.	Value.	Ownership.
Arctic Packing Co. (A. P. A.) Alaska Packing Co. Nushagak Bristol Bay Canning Co. Bay.	Oriental	Ship	1,550	Fishermen	$55,000	Chartered.
	Eclipse	do	1,469	Fishermen	35,000	Do.
	Tacoma	do	1,671	Fishermen	60,000	Owned.
Pacific Steam Whaling Co., Nushagak Bay.	Undaunted	Bark	1,647	Fishermen	35,000	Chartered.
Alaska Fishermen's Packing Co., Nushagak Bay.	Harry Morse	do	1,241	Fishermen	20,000	Do.
Point Roberts Packing Co. (A.P.A.) Kvichak Packing Co. Kvichak Bay.	Servia	Ship	1,736	Fishermen	55,000	Do.
	St. Nicholas	do	1,687	Fishermen	50,000	Do.
	Bohemia	do	1,528	Fishermen	55,000	Owned.
	Prosper	3-masted schooner	229	Fishermen	15,000	Do.
Arctic Packing Co. (A. P. A.), Naknek River.	Indiana[1]	Ship	1,413	Fishermen	50,000	Do.
	Merom[2]	Bark	1,134	Fishermen	50,000	Do.
Naknek Packing Co., Naknek River	B. P. Cheney	do	1,200	Fishermen	20,000	Owned.
Egegak Packing Co. (A. P. A.), Egegak River.	Charles B. Kenney	do	1,014	Fishermen	30,000	Chartered.
	Will W. Case	do	554	Fishermen	18,000	Owned.
Ugashik Fishing Station (A. P. A.), Ugashik River.	Coryphene	do	733	Fishermen	15,000	Chartered.
	Nicolas Thayer	do	555	Fishermen	15,000	Owned.
	Premier	3-masted schooner	292	Fishermen	15,000	Do.
Bristol Packing Co., Ugashik River.	Agate	Bark	595	Fishermen	10,000	Do.
Chignik Bay Co. (A. P. A.), Chignik Lagoon.	George Skolfield	Ship	1,275	Fishermen	20,000	Do.
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	(Transports by calling vessel of company.)					
Hume Bros. & Hume, Anchorage Bay, Chignik.	Ferris S. Thompson	Bark	480	11	12,000	Owned.
	Maid of Orleans	Schooner	171	8	8,000	Do.
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.	Electra	Bark	939	Fishermen	15,000	Do.
Karluk Packing Co. (A. P. A.), Karluk.						
Alaska Improvement Co. (A.P.A.), Karluk.	Santa Clara	Ship	1,453	Fishermen	40,000	Do.
Uganuk Fishing Station (A. P. A.), Uganuk Bay.						
Pacific Steam Whaling Co., Uyak Bay.	(Transports by calling vessel of company.)					
Hume Bros. & Hume, Uyak Bay	Harvester	Bark	716	12	12,000	Owned.
Alaska Salmon Association, Chuitna River.	Prussia	do	1,131	Fishermen	25,000	Chartered.
Pacific Steam Whaling Co., Kenai.	(Transports by calling vessel of company.)					
Arctic Fishing Co. (A. P. A.), Kussilof River.	Centennial	Ship	1,138	Fishermen	30,000	Owned.
Pacific Packing Co. (A. P. A.), Odiak	Kate Davenport	Bark	1,175	Fishermen	10,000	Chartered.
Pacific Steam Whaling Co., Orca	America	Ship	1,908	Fishermen	55,000	Do.
Western Fisheries Co., Dundas Bay.	(Transports by regular line of steamers.)					
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	Two Brothers	Ship	1,263	Fishermen	35,000	Owned.
Chilkoot Packing Co., Chilkoot Inlet.	(Transports by regular line of steamers.)					
Taku Packing Co., Taku Inlet	(Transports by regular line of steamers.)					
Taku Fishing Co., Port Snettisham.	(Transports by regular line of steamers.)					
Icy Strait Packing Co., Petersburg, Wrangell Narrows.	Blanche	Schooner hulk	107	Fishermen	4,500	Owned.
	Elliot	Barge	43	Fishermen	1,000	Do.
Royer-Warnock Packing Co., Beecher Pass.	(Transports by regular line of steamers.)					
Glacier Packing Co. (A. P. A.), Point Highfield.	Llewellyn J. Morse	Ship	1,271	Fishermen	35,000	Owned.
Thlinket Packing Co., Gerard Point	(Transports by regular line of steamers.)					
Fidalgo Island Canning Co., Ketchikan.	(Transports by regular line of steamers.)					
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.	Sintram	Ship	1,495	Fishermen	50,000	Chartered.
Boston Fishing and Trading Co., Yes Bay.	(Transports by regular line of steamers.)					
Quadra Packing Co., Mink Arm, Boca de Quadra.	(Transports by regular line of steamers.)					
Metlakahtla Industrial Co., Metlakahtla.	(Transports by regular line of steamers.)					
North Pacific Trading and Packing Co., Klawak.	(Transports by special sail charter.)					
Pacific Steam Whaling Co., Hunter Bay.	(Transports by calling vessel of company.)					

[1] Also called at Karluk.

[2] Lost October 1900, at Karluk.

RECAPITULATION.

	No.	Net tonnage.	Value.
Steam	78	2,757	$856,280
Sail	33	34,813	925,500
Total	111	37,570	1,781,780

Labor employed, 1898.

Name of company and location of cannery.	Fishermen.		Other employees.			Total employees.
	White.	Native.	White.	Native.	Chinese.	
Arctic Packing Co / Alaska Packing Co / Bristol Bay Canning Co. (A. P. A.), Nushagak Bay	160	.....	51	75	306	592
Point Roberts Packing Co. (A. P. A.), Kvichak Bay	76	.....	25	25	300	426
Arctic Packing Co. (A. P. A.), Naknek River	40	.....	36	30	102	208
Naknek Packing Co., Naknek River	56	.....	11	8	95	170
Ugashik Fishing Station (A. P. A.), Ugashik River	50	.....	18	30	100	198
Chignik Bay Co. (A. P. A.), Chignik Lagoon	70	.....	[1]23	.....	100	193
Pacific Steam Whaling Co., Anchorage Bay, Chignik	60	.....	10	4	60	134
Hume Bros. & Hume, Anchorage Bay, Chignik	52	.....	10	6	60	128
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak	29	.....	9	15	59	112
Karluk Packing Co. (A. P. A.), Karluk / Alaska Improvement Co. (A. P. A.), Karluk / Hume-Aleutian Packing Co. (A. P. A.), Karluk / Uganuk Fishing Station (A. P. A.), Uganuk Bay	171	34	57	.....	393	655
Pacific Steam Whaling Co., Uyak Bay	52	13	6	4	52	127
Hume Bros. & Hume, Uyak Bay	50	6	12	.....	60	128
Pacific Steam Whaling Co., Kenai	32	10	6	6	60	114
Arctic Fishing Co. (A. P. A.), Kussilof River	40	10	10	.....	100	160
Pacific Packing Co. (A. P. A.), Odiak	60	6	30	6	60	162
Pacific Steam Whaling Co., Orca	60	.....	13	.....	60	133
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor	88	[2]12	12	[3]15	86	213
Glacier Packing Co. (A. P. A.), Point Highfield	24	150	7	4	86	271
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring	90	100	15	25	130	360
Boston Fishing and Trading Co., Yes Bay	12	13	4	13	31	73
Quadra Packing Co., Mink Arm, Boca de Quadra	[4]24	30	5	[5]30	45	134
Metlakahtla Industrial Co., Metlakahtla	.....	[6]23	.....	162	.....	185
Baranoff Packing Co., Redfish Bay	.....	17	3	6	31	57
North Pacific Trading and Packing Co., Klawak	.....	30	17	[7]57	14	118
Pacific Steam Whaling Co., Hunter Bay	18	([8])	10	.....	60	88
Total employees	1,314	454	400	521	2,450	5,139

Labor employed, 1899.

Arctic Packing Co / Alaska Packing Co / Bristol Bay Canning Co (A. P. A.), Nushagak Bay	160	.....	51	75	336	622
Pacific Steam Whaling Co., Nushagak Bay	38	.....	14	15	50	117
Alaska Fishermen's Packing Co., Nushagak Bay	34	.....	5	35	63	137
Point Roberts Packing Co. (A. P. A.), Kvichak Bay	91	.....	25	25	300	441
Arctic Packing Co. (A. P. A.), Naknek River	48	.....	42	30	102	222
Naknek Packing Co., Naknek River	62	.....	13	10	95	180
Ugashik Fishing Station (A. P. A.), Ugashik River	50	.....	18	30	100	198
Chignik Bay Co. (A. P. A.), Chignik Lagoon	70	.....	[1]23	.....	102	195
Pacific Steam Whaling Co., Anchorage Bay, Chignik	60	.....	10	4	60	134
Hume Bros. & Hume, Anchorage Bay, Chignik	52	.....	10	6	65	133
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak	30	.....	9	15	59	113
Karluk Packing Co. (A. P. A.), Karluk / Alaska Improvement Co. (A. P. A.), Karluk / Hume-Aleutian Packing Co. (A. P. A.), Karluk / Uganuk Fishing Station, (A. P. A.), Uganuk Bay	176	34	57	.....	393	660
Pacific Steam Whaling Co., Uyak Bay	60	26	6	4	52	148
Hume Bros. & Hume, Uyak Bay	50	6	12	.....	60	128
Pacific Steam Whaling Co., Kenai	32	10	6	6	60	114
Arctic Fishing Co. (A. P. A.), Kussilof River	42	10	10	.....	100	162
Pacific Packing Co. (A. P. A.), Odiak	60	6	30	6	60	162
Pacific Steam Whaling Co., Orca	60	.....	13	.....	60	133
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor	88	[9]12	12	[3]17	86	215
Glacier Packing Co. (A. P. A.), Point Highfield	24	150	7	4	86	271
Thlinket Packing Co., Gerard Point	12	19	[10]6	[3]20	16	73
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring	100	150	20	25	130	425
Boston Fishing and Trading Co., Yes Bay	15	15	5	15	40	90
Quadra Packing Co., Mink Arm, Boca de Quadra	26	40	5	[5]29	45	145
Metlakahtla Industrial Co., Metlakahtla	.....	[11]24	.....	17	.....	41
North Pacific Trading and Packing Co., Klawak	17	.....	17	[12]57	20	111
Pacific Steam Whaling Co., Hunter Bay	18	([13])	10	.....	60	88
Total employees	1,475	502	436	445	2,600	5,458

[1] Includes 3 coal miners.
[2] Purchased fish from 192 natives.
[3] Klootchmen.
[4] Labor figures approximate.
[5] Includes 25 Klootchmen.
[6] Purchased fish from 32 natives.
[7] Includes 12 men, 25 women, 20 children.
[8] Purchased fish from 50 natives.
[9] Purchased fish from 196 natives.
[10] Includes 1 woman, cooking.
[11] Purchased fish from 36 natives.
[12] Includes 12 men, 25 women, 20 children.
[13] Purchased fish from 150 natives.

Labor employed, 1900.

Name of company and location of cannery.	Fishermen.		Other employees.			Total employees.
	White.	Native.	White.	Native.	Chinese.	
Arctic Packing Co., Alaska Packing Co., Bristol Bay Canning Co. (A. P. A.), Nushagak Bay	215	.....	66	75	450	806
Pacific Steam Whaling Co., Nushagak Bay	56	.....	10	35	100	201
Alaska Fishermen's Packing Co., Nushagak Bay	55	.....	7	35	93	190
Point Roberts Packing Co., Kvichak Packing Co. (A. P. A.), Kvichak Bay	154	.....	25 13	25 8	[1] 300 [2] 147	672
Arctic Packing Co. (A. P. A.), Naknek River	58	.....	54	20	140	272
Naknek Packing Co., Naknek River	60	.....	12	11	131	214
Egegak Packing Co. (A. P. A.), Egegak River	39	.....	16	10	80	145
Ugashik Fishing Station (A. P. A.), Ugashik River	64	.....	24	20	140	248
Bristol Packing Co., Ugashik River	27	.....	6	10	48	91
Chignik Bay Co. (A. P. A.), Chignik Lagoon	63	.....	[3] 20	2	90	175
Pacific Steam Whaling Co., Anchorage Bay, Chignik	60	.....	10	4	60	134
Hume Bros. & Hume, Anchorage Bay, Chignik	52	.....	10	6	58	126
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak	40	.....	9	10	59	118
Karluk Packing Co. (A. P. A.), Karluk, Alaska Improvement Co. (A. P. A.), Karluk, Uganuk Fishing Station (A. P. A.), Uganuk Bay	171	13	43	8	263	498
Pacific Steam Whaling Co., Uyak Bay	64	26	6	4	56	156
Hume Bros. & Hume, Uyak Bay	52	9	12	.....	56	129
Alaska Salmon Association, Chuitna River	39	.....	16	.....	51	106
Pacific Steam Whaling Co., Kenai	40	10	6	6	60	122
Arctic Fishing Co. (A. P. A.), Kussilof River	45	10	10	.....	100	165
Pacific Packing Co. (A. P. A.), Odiak	60	6	30	6	60	162
Pacific Steam Whaling Co., Orca	60	.....	13	2	60	135
Western Fisheries Co., Dundas Bay	9	26	5	[4] 26	30	96
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor	102	[5] 10	12	[6] 16	86	226
Chilkoot Packing Co., Chilkoot Inlet	24	[7] 8	9	17	28	86
Taku Packing Co., Taku Inlet	30	14	7	2	19	72
Taku Fishing Co., Port Snettisham	16	20	4	.....	25	65
Icy Strait Packing Co., Petersburg, Wrangell Narrows	26	28	7	[8] 42	50	153
Royer-Warnock Packing Co., Beecher Pass	([9])	([9])	2	.....	[10] 11	13
Glacier Packing Co. (A. P. A.), Point Highfield	24	150	7	4	86	271
Thlinket Packing Co., Gerard Point	35	30	9	[11] 7	49	130
Fidalgo Island Canning Co., Ketchikan	34	[12] 41	7	[13] 50	50	182
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring	100	150	20	40	120	430
Boston Fishing and Trading Co., Yes Bay	15	15	5	15	61	111
Quadra Packing Co., Mink Arm, Boca de Quadra	24	40	5	[6] 25	43	137
Metlakahtla Industrial Co., Metlakahtla	.....	[14] 24	.....	174	174	372
North Pacific Trading and Packing Co., Klawak	.....	55	16	[15] 13	46	130
Pacific Steam Whaling Co., Hunter Bay	21	([16])	10	.....	90	121
Total employees	1,934	685	543	728	3,570	7,460

[1] Includes a few Japanese.
[2] Chinese and Japanese.
[3] Includes 3 coal miners.
[4] Includes 6 Klootchmen.
[5] Purchased fish from 224 natives.
[6] Klootchmen.
[7] Purchased fish from 16 natives in addition.
[8] Includes 28 Klootchmen.
[9] Purchased all fish.
[10] 10 Japanese; 1 Chinaman.
[11] Includes 5 Klootchmen.
[12] Includes 3 Japanese.
[13] Includes 40 Klootchmen.
[14] Purchased fish from 38 natives in addition.
[15] 3 Bucks; 10 Klootchmen.
[16] Purchased fish from 121 natives.

Net equipment, 1898.

Name of company and location of cannery.	Gill nets.			Seines.			Traps.		
	No.	Description.	Value per fathom.	No.	Description.	Value per fathom.	No.	Description.	Average value.
Arctic Packing Co. (A. P. A.), Nushagak.	120	Redfish, 75 fms. by 24 m by 6½ in.	$0.65				1	Double; total leads 2,700 ft.; pots 75 ft. square.	$4,000
Alaska Packing Co. (A. P. A.), Nushagak.	60	King, 125 fms. by 24 m. by 9¼ in.	.65				3	Single; inshore leads 300 to 500 ft.; pots 40 ft. square.	1,200
Bristol Bay Canning Co. (A. P. A.), Nushagak.									
Point Roberts Packing Co. (A. P. A.), Kvichak Bay.	40	Redfish, 75 fms. by 20 m. by 6⅛ in.	.65				2	1 double, 1 single; leads vary; pots 40 ft. square.	1,000
Arctic Packing Co. (A. P. A.), Naknek River.	36	Redfish, 65 fms. by 20 m. by 6¼ in.	.65				2	Single; inshore leads are 775 ft.; channel, 1,500 ft.; pots 40 ft. square.	1,200
Naknek Packing Co., Naknek River.	20	Redfish, 75 fms. by 22 m. by 6¼ in.	.65						
Ugashik Fishing Station (A. P. A.), Ugashik River.	42	Redfish, 85 fms. by 26 m. by 6⅛ in.	.65				2	Single; inshore leads are 500 ft.; pots 40 ft. square.	1,000
Chignik Bay Co. (A. P. A.), Chignik Lagoon.	10	Redfish, 135 fms. by 30 m. by 6⅛ in.	.65	4	Drag, 75 to 180 fms. by 120 to 180 m. by 3 to 3½ in.	$1.50	10	Single; average shore leads 1,000 ft.; pots 40 ft. square.	1,500
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	11	Redfish, 260 fms. by 30 m. by 6 in.	.65	1	Drag, 300 fms. by 22 ft. by 3 in.	1.50	10	Single; average shore leads 600 ft.; pots 40 ft. square.	1,500
				3	Drag, 200 fms. by 22 ft. by 3 in.	1.50			
Hume Bros. & Hume, Anchorage Bay, Chignik.	11	Redfish, 150 fms. by 26 and 40 m. by 6 in.	.65	1	Drag, 150 fms. by 25 ft. by 3 in.	1.50	7	5 single, 2 double; average shore and channel leads 800 ft. each; pots 40 ft. square.	1,500
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.				5	Drag, average 200 fms. by 80 to 120 m. by 3 in.	1.50			
				1	Purse, 400 fms. (not rigged).				
Karluk Packing Co. (A. P. A.), Karluk.				10	Drag, 400 fms. by 185 m. by 3 in.	1.50			
Alaska Improvement Co. (A. P. A.), Karluk.				6	Drag, 250 to 300 fms. by 120 to 160 m. by 3 in.	1.50	2	Floating; shore leads 1,200 and 1,800 ft. at Uganuk.	1,500
Hume-Aleutian Packing Co. (A. P. A.), Karluk.				3	Drag, 100 fms. by 80 m. by 3 in. (hatchery).	1.50			
Uganuk Fishing Station (A. P. A.), Uganuk Bay.									
Pacific Steam Whaling Co., Uyak Bay.				1	Drag, 700 fms. by 180 m. by 3 in.	1.50			
				1	Drag, 550 fms. by 180 m. by 3 in.				
				3	Drag, 350 fms. by 180 m. by 3 in.				
					(Also 10 spare seines of various sizes in reserve.)				
Hume Bros. & Hume, Uyak Bay.				8	Drag, 150 to 350 fms. by 100 to 160 m. by 3 in.	1.50			
Pacific Steam Whaling Co., Kenai.	10	King, 60 fms. by 22 m by 9½ in.	.65	1	Drag, 150 fms. 3 in.	1.50	4	Single; leads 600 ft.; pots 30 ft. square.	300
	10	Redfish, 60 fms. by 30 m. by 6 in.	.65						
Arctic Fishing Co. (A. P. A.), Kussilof River.	30	Redfish, 60 fms. by 28 m. by 6⅛ in.	.65				6	Single; leads 100 to 700 ft.; pots 30 ft. square.	1,000
	30	King, 60 fms. by 22 m. by 9¼ in.	.65						
Pacific Packing Co. (A. P. A.), Odiak.	38	Redfish, 350 fms. by 30 m. by 6½ in.	.65	1	Drag, 250 fms. by 120 m. by 2½ in.	1.50			
Pacific Steam Whaling Co., Orca.	30	Redfish, 400 fms. by 28 m. by 6 to 6¼ in.	.65	2	Drag, 120 fms. by 140 m. by 3 in.	1.50			
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	50	Redfish, 300 fms. by 28 m. by 6⅛ in.	.65						
	14	King, 180 fms. by 30 m. by 8⅛ in.	.65						
Glacier Packing Co. (A. P. A.), Point Highfield.	12	King, 250 fms. by 28 m. by 8½ in.	.65	2	Drag, 120 fms. by 200 m. by 3 in.	1.50			
	12	Redfish, 250 fms by 30 m. by 6¼ in.	.65	5	Purse, 120 fms. by 250 m. by 3 in.	2.00			

Net equipment, 1898—Continued.

Name of company and location of cannery.	Gill nets.			Seines.			Traps.		
	No.	Description.	Value per fathom.	No.	Description.	Value per fathom.	No.	Description.	Average value.
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.				7	Purse, 150 to 200 fms. by 7 to 12 m. by 3 in.	$2.50			
				10	Drag, 150 to 200 fms. by 4 to 6 m. by 3 in.	1.50			
Boston Fishing and Trading Co., Yes Bay.				1	Purse, 230 fms. by 20 fms. by 3 in.	2.50	1	Double; shore lead 300 ft.; channel, 100 ft; 1 pot 30 ft. square, 1 pot 28 ft. square.	$1,000
				3	Drag, 175, 150, 120 fms. by 10, 8, 6 fms. by 3 in.	1.50			
Quadra Packing Co., Mink Arm, Boca de Quadra.	36	Redfish, 50 fms. by 40 m. by 5½ to 6 in.	$0.65	8	Purse, 135 to 180 fms. by 12 to 15 fms. by 3 in.	3.00			
	36	Coho, 75 fms. by 30 m. by 7 in.	.65						
	36	King, 50 fms. by 25 m. by 9 in.	.65	2	Drag, 115 fms. by 8 fms. by 3 in.	2.00			
Metlakahtla Industrial Co., Metlakahtla.	8	Redfish, average 172 fms. by 4 fms. by 5½ in.	.65	6	Purse, average 158 fms. by 8½ fms. by 3 in.	3.00			
				9	Drag, average 163 by 6 fms. by 3 in.	1.50			
Baranoff Packing Co., Redfish Bay.				2	Drag, 125 fms. by 3 in.	1.50			
North Pacific Trading and Packing Co., Klawak.				3	Purse, 175 fms. by 240 m. by 3 in.	1.50			
Pacific Steam Whaling Co., Hunter Bay.				15	Combination purse and drag, average 195 by 5 fms. by 3 in. mesh.	1.50			

Net equipment, 1899.

Name of company and location of cannery.	Gill nets.			Seines.			Traps.		
	No.	Description.	Value per fath.	No.	Description.	Value per fath.	No.	Description.	Value, each.
Arctic Packing Co. (A. P. A.), Nushagak Bay.	120	Redfish, 75 fms. by 24 m. by 6⅛ in.	$0.65				1	Double; total leads 2,700 ft.; pots 75 ft. square.	$4,000
Alaska Packing Co. (A. P. A.), Nushagak Bay.									
Bristol Bay Canning Co. (A. P. A.). Nushagak Bay.	60	King, 125 fms. by 24 m. by 9¼ in.	.65				4	Single; inshore leads 300 to 500 ft.; pots 40 ft. square.	1,200
Pacific Steam Whaling Co., Nushagak.	30	Redfish, 75 fms. by 24 m. by 6½ in.	.65						
	30	King, 125 fms. by 24 m. by 9½ in.	.65						
Alaska Fishermen's Packing Co., Nushagak.	30	Redfish, 70 fms. by 30 m. by 6½ in.	.75						
	25	King, 70 fms. by 22 m. by 10 in.	.75						
Point Roberts Packing Co. (A. P. A.), Koggiung, Kvichak River.	60	Redfish, 75 fms. by 20 m. by 6⅛ in.	.65				2	1 double, 1 single; leads vary; pots 40 ft. square.	1,000
Arctic Packing Co. (A. P. A.), Naknek River.	48	Redfish, 75 fms. by 20 m. by 6⅛ in.	.65				3	Single; inshore leads 800 ft.; channel 1,600 ft.; pots 40 ft. square.	1,200
Naknek Packing Co., Naknek River.	20	Redfish, 75 fms. by 22 m. by 6½ in.	.65						
Ugashik Fishing Station (A. P. A.), Ugashik.	42	Redfish, 85 fms. by 26 m. by 6⅛ in.	.65				3	Single; inshore leads average 500 ft.; pots 40 ft. square.	1,000
Chignik Bay Co. (A.P.A.), Chignik Lagoon.	10	Redfish, 135 fms. by 30 m. by 6⅛ in.	.65	4	Drag, 75 to 180 fms. by 120 to 180 m. by 3 to 3⅛ in.	$1.50	10	Single; aver. shore leads 1,000 ft.; pots 40 ft. square.	1,500
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	12	Redfish, 260 fms. by 30 m. by 6 in.	.65	2	Drag, 200 fms. by 22 ft. by 3 in.	1.50	8	Single; aver. shore leads 600 ft.; pots 40 ft. square.	1,500
				1	Drag, 300 fms. by 22 ft. by 3 in.	1.50			
Hume Bros. & Hume, Anchorage Bay, Chignik.	11	Redfish, 150 fms. by 26 to 40 m. by 6 in.	.65	1	Drag, 150 fms. by 25 ft. by 3 in.	1.50	7	5 single; 2 double; aver. shore and channel leads 800 ft. each; pots 40 ft. square.	1,500

Net equipment, 1899—Continued.

Name of company and location of cannery.	Gill nets.			Seines.			Traps.		
	No.	Description.	Value per fath.	No.	Description.	Value per fath.	No.	Description.	Value per fath.
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.				6	Drag, average 200 fms. by 100 to 130 m. by 3 in.	$1.50	1	Floating; lead 100 ms.; pot 40 by 90 ft.	$2,500
				1	Purse, 400 fms. (not rigged).	3.00			
Karluk Packing Co. (A. P. A.), Karluk.				10	Drag, 400 fms. by 185 m. by 3 in.	1.50			
Alaska Improvement Co. (A. P. A.), Karluk.				6	Drag, 250 to 300 fms. by 120 to 160 m. by 3 in.	1.50	2	Floating; shore leads 1,200 and 1,800 ft. at Uganuk.	1,500
Hume-Aleutian Packing Co. (A. P. A.), Karluk.				3	Drag, 100 fms. by 80 m. by 3 in. (Hatchery.)	1.50			
Uganuk Fishing Station (A. P. A.), Uganuk Bay.									
Pacific Steam Whaling Co., Uyak Bay.				1	Drag, 700 fms. by 180 m. by 3 in.	1.50			
				1	Drag, 550 fms. by 180 m. by 3 in.	1.50		(Also 10 spare seines of various sizes, in reserve.)	
				3	Drag, 350 fms. by 180 m. by 3 in.	1.50			
Hume Bros. & Hume, Uyak Bay.				8	Drag, 150 to 350 fms. by 100 to 160 m. by 3 in.	1.50			
Pacific Steam Whaling Co., Kenai.	20	Redfish, 60 fms. by 30 m. by 6 in.	$0.65	1	Drag, 150 fms. by 3 in.	1.50	5	Single; leads average 1,000 ft.; pots 30 ft. square.	500
	20	King, 60 fms. by 22 m. by 9¼ in.	.65						
Arctic Fishing Co. (A. P. A.), Kussilof River.	30	Redfish, 60 fms. by 28 m. by 6⅛ in.	.65				8	Single; leads 100 to 700 ft.; pots 30 ft. square.	1,000
	30	King, 60 fms. by 22 m. by 9¼ in.	.65						
Pacific Packing Co. (A. P. A.), Odiak.	38	Redfish, 350 fms. by 30 m. by 6⅛ in.	.65	1	Drag, 250 fms. by 120 m. by 2½ in.	1.50			
Pacific Steam Whaling Co., Orca.	30	Redfish, 400 fms. by 28 m. by 6 to 6½ in.	.65	2	Drag, 120 fms. by 140 m. by 3 in.	1.50			
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	50	Redfish, 300 fms. by 28 m. by 6⅛ in.	.65						
	14	King, 180 fms. by 30 m. by 8⅛ in.	.65						
Glacier Packing Co. (A. P. A.), Wrangell, Point Highfield.	12	Redfish, 250 fms. by 30 m. by 6½ in.	.65	5	Purse, 120 fms. by 250 m. by 3 in.	2.00			
	12	King, 250 fms. by 28 m. by 8½ in.	.65	2	Drag, 120 fms. by 200 m. by 3 in.	1.50			
Thlinket Packing Co., Gerard Point.	10	Redfish, 200 fms. by 22 m. by 6½ in.	.65	2	Drag, 90 fms. by 190 m. by 3 in.	1.50			
	4	King, 200 fms. by 22 m. by 9¼ in.	.65	1	Drag, 65 fms. by 140 m. by 3 in.	1.50			
Alaska Salmon Packing and Fur Co., (A. P. A.). Loring.				15	Purse, 150 to 200 fms. by 7 to 12 fms. by 3 in.	2.50			
				10	Drag, 150 to 200 fms. by 4 to 6 fms. by 3 in.	1.50			
Boston Fishing and Trading Co., Yes Bay.				1	Purse, 230 fms. by 20 fms. by 3 in.	2.50	1	Double; shore lead 300 ft.; channel 100 ft.; 1 pot 30 ft. square; 1 pot 28 ft. square.	1,000
				3	Drag, 175 fms. by 10 fms. by 3 in.	1.50			
				3	Drag, 150 fms. by 8 fms. by 3 in.	1.50			
				3	Drag, 120 fms. by 6 fms. by 3 in.	1.50			
Quadra Packing Co., Mink Arm, Boca de Quadra.	36	Redfish, 50 fms. by 40 m. by 5⅛ to 6 in.	.65	9	Purse, 135 to 200 fms. by 12 to 15 fms. by 3 in.	3.00			
	36	Coho, 75 fms. by 30 m. by 7 in.	.65	2	Purse, 180 fms. by 15 fms. by 2 in. (herring).	2.50			
	36	King, 50 fms. by 25 m. by 9 in.	.65	2	Drag, 115 fms. by 8 fms. by 3 in.	2.00			
Metlakahtla Industrial Co., Metlakahtla.	7	Redfish, average 172 by 4 fms. by 5⅛ in.	.65	7	Purse, average 158 fms. by 8½ fms. by 3 in.	3.00			
				7	Drag, average 163 fms. by 6 fms. by 3 in.	1.50			
North Pacific Trading and Packing Co., Klawak.				3	Purse, 175 fms. by 240 m. by 3 in.	1.50			
Pacific Steam Whaling Co., Hunter Bay.				15	Combination purse and drag; average 195 fms. by 5 fms. by 3 in.	1.50			

Net equipment, 1900.

Name of company and location of cannery.	Gill nets.			Seines.			Traps.		
	No.	Description.	Value per fath.	No.	Description.	Value per fath.	No.	Description.	Aver. value.
Arctic Packing Co. (A. P. A.), Nushagak Bay.	160	Redfish, 75 fms. by 24 m. by 6½ in.	$0.65				1	Double; total leads, 2,700 ft.; pots, 75 ft. square.	$4,000
Alaska Packing Co. (A. P. A.), Nushagak Bay.	120	King, 125 fms. by 24 m. by 9¼ in.	.65				[3]	Single; inshore leads, 300 to 500 ft.; pots, 40 ft. square.	1,200
Bristol Bay Canning Co. (A. P. A.), Nushagak Bay	50	Redfish, 75 fms. by 24 m. by 6½ in.	.65						
Pacific Steam Whaling Co., Nushagak Bay.	44	King, 125 fms. by 24 m. by 9¼ in.	.65						
Alaska Fishermen's Packing Co., Nushagak Bay.	30	Redfish, 70 fms. by 30 m. by 6½ in.	.75						
	25	King, 70 fms. by 22 m. by 10 in.	.75						
Point Roberts Packing Co. (A. P. A.), Kvichak Bay. Kvichak Packing Co. (A. P. A.), Kvichak Bay.	100	Redfish, 75 fms. by 20 m. by 6½ in.	.65				1	Double; inshore leads, 60 ft.; channel leads, 300 ft.; pots, 40 ft. square.	1,000
Arctic Packing Co. (A. P. A.), Naknek River.	[1]76	Redfish, 75 fms. by 22 m. by 6½ in.	.65				[2]3	Single; inshore leads, 750 ft.; channel leads, 1,400 ft.; pots, 40 ft. square.	1,200
Naknek Packing Co., Naknek River.	21	Redfish, 75 fms. by 22 m. by 6½ in.	.65						
Egegak Packing Co. (A. P. A.), Egegak River.	20	Redfish, 80 fms. by 26 m. by 6½ in.	.65				[2]2	Single; inshore leads, 200 and 250 ft.; pots, 40 ft. square.	1,000
Ugashik Fishing Station (A. P. A.), Ugashik River.	48	Redfish, 85 fms. by 26 m. by 6½ in.	.65				3	Single; inshore leads, 500 ft., average; pots, 40 ft. square.	1,000
Bristol Packing Co., Ugashik River.	8	Redfish, 75 fms. by 23 m. by 6½ in.	.65						
Chignik Bay Co. (A. P. A.), Chignik Lagoon.	[4]10	Redfish, 135 fms. by 30 m. by 6½ in.	.65	[5]4	Drag, 75 to 180 fms. by 120 to 180 m. by 3 and 3½ in.	$1.50	6	Sing. Aver. inshore leads, 1,000 ft.; aver. channel leads, 900 ft.; pots, 40 ft. sq.	1,500
							2	Doub.	
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	10	Redfish, 260 fms. by 30 m. by 6 in.	.65	2	Drag, 200 fms. by 22 ft. deep by 3 in.	1.50	2	Sing. Aver. inshore and channel leads, each 800 ft.; pots, 40 ft. square.	1,500
				1	Drag, 300 fms. by 22 ft. deep by 3 in.	1.50	2	Doub.	
Hume Bros. & Hume, Anchorage Bay, Chignik.	15	Redfish, 150 fms. by 26 to 40 m. by 6 in.	.65	2	Drag, 150 fms. by 25 ft. deep by 3 in.	1.50	5	Sing. Aver. inshore and channel leads, each 800 ft.; pots, 40 ft. square.	1,500
							2	Doub.	
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.				1	Purse, 400 fms. (not rigged).	3.00	1	Floating; inshore lead, 100 fms.; pot, 40 by 90 ft.	2,500
				6	Drag, average 200 fms. by 100 to 130 m. by 3 in.	1.50			
Karluk Packing Co. (A. P. A.), Karluk. Alaska Improvement Co. (A. P. A.), Karluk. Uganuk Fishing Station, (A. P. A.), Uganuk Bay.				10	Drag, 400 fms. by 185 m. by 3 in.	1.50	2	Floating; inshore leads, 1,200 and 1,800 ft.; at Uganuk.	1,500
				6	Drag, 250 to 300 fms. by 120 to 160 m. by 3 in.	1.50			
				3	Drag, 100 fms. by 80 m. by 3 in. (hatchery).	1.50			
Pacific Steam Whaling Co., Uyak Bay.				1	Drag, 700 fms. by 180 m. by 3 in.	1.50		(Also 10 spare seines of various sizes, in reserve.)	
				1	Drag, 550 fms. by 180 m. by 3 in.				
				3	Drag, 350 fms. by 180 m. by 3 in.				
Hume Bros. & Hume, Uyak Bay.				10	Drag, 150 to 350 fms. by 160 m. by 3 in.	1.50			
Alaska Salmon Association, Chuitna River.	20	Redfish, 65 fms. by 30 m. by 5¾ in.	.65						
	20	Redfish and cohoes, 65 fms. by 30 m. by 6½ in.	.65	1	Drag, 150 fms. by 5 fms. by 3 in.	1.65	4	Single; inshore leads, 600 ft.; pots, 40 ft. square.	1,500
	20	King, 65 fms. by 30 m. by 9 in.	.65						
Pacific Steam Whaling Co., Kenai.	20	Redfish, 60 fms. by 30 m. by 6 in.	.65						
	20	King, 60 fms. by 22 m. by 9¼ in.	.65	1	Drag, 150 fms., 3 in.	1.50	5	Single; inshore leads average 1,000 ft.; pots, 30 ft. square.	500

[1] 47 of these nets not in use; reserve.
[2] 1 of these traps not equipped with web; reserve.
[3] Traps on hand but not in use; reserve.
[4] Only 1 gill net in use; 9 in reserve.
[5] 1 seine not used; reserve.

Net equipment, 1900—Continued.

Name of company and location of cannery.	Gill nets.			Seines.			Traps.		
	No.	Description.	Value per fath.	No.	Description.	Value per fath.	No.	Description.	Aver. value.
Arctic Fishing Co. (A. P. A.), Kussilof River.	30	Redfish, 60 fms. by 28 m. by 6⅛ in.	$0.65				8	Single; leads from 100 to 700 ft.; pots, 30 ft. square.	$1,000
	30	King, 60 fms. by 22 m. by 9⅛ in.	.65						
Pacific Packing Co. (A. P. A.), Odiak	38	Redfish, 350 fms. by 30 m. by 6⅛ in.	.65	1	Drag, 250 fms. by 120 m. by 2½ in.	$1.50			
Pacific Steam Whaling Co., Orca.	30	Redfish, 400 fms. by 28 m. by 6¼ in.	.65	2	Drag, 120 fms. by 40 m. by 3 in.	1.50			
Western Fisheries Co., Dundas Bay.	4	150 fms. long	.65	1	Purse, 150 fms. long.	3.00			
				6	Drag, average 100 fms. in length.	1.50			
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	56	Redfish, 300 fms. by 28 m. by 6⅛ in.	.65						
	14	King, 180 fms. by 30 m. by 8⅛ in.	.65						
Chilkoot Packing Co., Chilkoot Inlet.	16	Redfish, 270 fms. by 25 m. by 6½ in.	.65	1	Purse, 160 fms. by 20 fms. by 3¾ in.	(1)			
Taku Packing Co., Taku Inlet.	15	Redfish, 150 fms. by 35 m. by 6¼ in.	.65						
	22	King, 150 fms. by 22 m. by 9⅛ in.	.65						
Taku Fishing Co., Port Snettisham.	14	Redfish, 150 fms. by 30 m. by 6⅛ in.	.65	1	Purse, 165 fms. by 300 m. by 3⅛ in.	(2)			
	4	King, 150 fms. by 20 m. by 9¼ in.	.65	3	Drag, 100 fms. by 5 fms. by 3⅛ in.	1.50			
				5	Purse, 120 fms. by 10 fms. by 3 in.	3.00			
Icy Strait Packing Co., Petersburg, Wrangell Narrows.	120	Redfish, 50 fms. by 40 m. by 5¾ in.	.65	5	Drag, 120 fms. by 6 fms. by 3 in.	1.50			
		Cohoes, 75 fms. by 30 m. by 7 in.	.65	2	Combination, 180 by 15 fms. by 2 in. (herring).	3.00			
		King, 50 fms. by 25 m. by 9 in.	.65						
Royer-Warnock Packing Co., Beecher Pass.	1	Cohoes, 100 fms. by 30 m. by 7 in.	.65	2	Drag, 100 fms. by 5 fms. by 3 in.	1.50			
Glacier Packing Co. (A. P. A.), Point Highfield.	12	Redfish, 250 fms. by 30 m. by 6⅛ in.	.65	5	Purse, 120 fms. by 250 m. by 3 in.	2.00			
	12	King, 250 fms. by 28 m. by 8½ in.	.65	2	Drag, 120 fms. by 200 m. by 3 in.	1.50			
Thlinket Packing Co., Point Gerard.	12	Redfish, 200 fms. by 24 m. by 6½ in.	.65	1	Purse, 185 fms. by 220 m. by 3 in.	(3)	4	Single; inshore leads average 750 ft.; pots, 36 ft. square.	1,375
	13	King, 200 fms. by 22 m. by 9¼ in.	.65	1	Purse, 100 fms. by 160 m. by 3 in.				
				4	Drag, 100 fms. by 178 m. by 3 in.	1.50			
Fidalgo Island Canning Co., Ketchikan.				8	Purse, 175 fms. by 10 to 12 fms. by 3 in.	3.00			
				2	Drag, 160 fms. by 6 fms. by 3⅛ in.	1.75			
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.				24	Purse, 150 to 200 fms. by 7 to 12 fms. by 3 in.	2.50			
				16	Drag, 150 to 200 fms. by 4 to 6 fms. by 3 in.	1.50			
Boston Fishing and Trading Co., Yes Bay.	2	Redfish, 100 fms. by 35 m. by 6⅛ in.	.65	1	Purse, 230 fms. by 20 fms. by 3 in.	2.50	1	Double; inshore lead, 300 ft.; channel lead, 100 ft.; 1 pot, 30 ft. square, 1 pot, 28 ft. square.	1,000
	2	King, 100 fms. by 32 m. by 10⅛ in.	.65	3	Drag, 175 fms. by 10 fms. by 3 in. Drag, 150 fms. by 8 fms. by 3 in. Drag, 120 fms. by 6 fms. by 3 in.	1.50			
Quadra Packing Co., Mink Bay, Boca de Quadra.				8	Purse, 180 fms. by 15 fms. by 3 in., average.	3.00			
				1	Drag, 115 fms. by 8 fms. by 3 in.	2.00			
Metlakahtla Industrial Co., Metlakahtla.	5	(Average) 172 fms. by 4 fms. by 5⅛ in.	.65	8	Purse (average), 158 fms. by 8½ fms. by 3 in.	3.00			
				4	Drag (average), 163 fms. by 6 fms. by 3 in.	1.50			
North Pacific Trading and Packing Co., Klawak.				9	Purse, 175 fms. by 240 m. by 3 in.	(4)			
Pacific Steam Whaling Co., Hunter Bay.				22	Combination (average), 195 fms. by 5 fms. by 3 in.	1.50			

[1] Whole cost, $1,400. [2] Whole cost, $400. [3] $500 each. [4] $300 each.

Boat equipment, 1898.

Name of company and location of cannery.	Unrigged vessels.			Boats, etc.		
	No.	Description.	Value each.	No.	Description.	Value each.
Arctic Packing Co. (A. P. A.) Nushagak.	18	Lighters	$600	60	Columbia River gill-net boats.	$200
Alaska Packing Co. (A. P. A.) Nushagak.	2	Pile-drivers	1,200	25	Skiffs	30
Bristol Bay Canning Co. (A. P. A.) Nushagak.						
Point Roberts Packing Co. (A. P. A.), Koggiung, Kvichak River.	6	Lighters	800	20	Gill-net boats, F. B[1]	100
	6	Trap scows	100	10	Skiffs	30
	2	Pile-drivers	1,500			
Arctic Packing Co. (A. P. A.), Naknek River.	5	Lighters	500	19	Gill-net boats, F. B	85
	1	Pile-driver	1,200	10	Skiffs	40
Naknek Packing Co., Naknek River	7	Lighters	600	23	Gill-net boats, F. B	100
				5	Skiffs	25
Ugashik Fishing Station (A. P. A.), Ugashik.	9	do	800	24	Columbia River boats	200
	1	Pile-driver	1,500	10	Skiffs	25
	2	Sail lighters	1,500	3	Seine boats, F. B	100
Chignik Bay Co. (A. P. A.), Chignik Lagoon.	1	do	750	7	Columbia River boats	200
	10	Trap scows	250	8	Gill-net boats, F. B	100
	3	Pile-drivers	750	12	Skiffs	25
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	4	Lighters	400	3	Seine boats	75
	1	Sail scow	200	9	Columbia River boats	200
	10	Trap scows	60	3	Gill-net boats, F. B	100
	3	Pile-drivers	1,000	10	Skiffs	25
Hume Bros. & Hume, Anchorage Bay, Chignik.	13	Lighters	140	2	Seine boats	70
	1	Sail scow	600	8	Columbia River boats	200
	1	do	300	10	Gill-net boats, F. B	100
	2	Pile-drivers	1,050	14	Skiffs	25
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.	1	Cargo lighter	500	6	Seine boats, F. B	60
	2	Fish lighters	250	1	Otter boat	100
	2	Fish scows	100	18	Dories	30
	1	Hand pile-driver	100	3	Skiffs	15
Karluk Packing Co. (A. P. A.) Karluk and Uganuk Bay.	7	Lighters	500	18	Seine boats, F. B	150
Alaska Improvement Co. (A. P. A.) Karluk and Uganuk Bay.	12	Fish scows	150	33	Dories	25
				3	Launch tenders	90
Hume-Aleutian Pkg. Co. (A. P. A.) Karluk and Uganuk Bay.	1	Hatchery scow	150	6	Hatchery cars	30
				11	Seine boats, F. B	70
Uganuk Fishing Station (A. P. A.) Karluk and Uganuk Bay.				3	Sail boats	90
				10	Dories	30
Pacific Steam Whaling Co., Uyak Bay	4	Lighters	450	9	Seine boats	120
	1	Pile-driver	1,000	1	Whitehall boat	75
Hume Bros. & Hume, Uyak Bay	3	Lighters	400	17	Dories	20
	1	Pile-driver	1,000	2	Skiffs	25
				1	Seine boat	100
Pacific Steam Whaling Co., Kenai	5	Lighters	400	10	Gill-net boats, F. B	40
	1	Pile-driver	1,500	3	Skiffs	25
Arctic Fishing Co. (A. P. A.), Kussilof River.	3	Sail lighters	450	15	Gill-net boats, F. B	40
	4	Trap scows	50	4	Skiffs	30
	1	Pile-driver	1,500			
Pacific Packing Co. (A. P. A.), Odiak	2	Lighters	400	2	Seine boats	200
	3	Scows	400	33	Columbia River boats	200
				6	Skiffs	25
Pacific Steam Whaling Co., Orca	4	House scows	400	2	Seine boats	200
	1	Pile-driver	200	30	Columbia River boats	200
				8	Skiffs	25
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	3	Lighters	700	50	Columbia River boats	200
	1	Pile-driver	1,000	3	Skiffs	25
				7	Seine boats	60
Glacier Packing Co. (A. P. A.), Point Highfield.	2	Lighters	600	14	Columbia River boats	200
				8	Old River boats	25
				5	Skiffs	25
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.	2	Cargo lighters	150	17	Seine boats	50
	20	Fish lighters	75	1	Whitehall boat	50
				12	Skiffs	20
Boston Fishing and Trading Co., Yes Bay	5	Lighters	50	4	Seine boats	50
				6	Skiffs	25
Quadra Packing Co., Boca de Quadra	2	House scows	75	12	Gill-net boats, F. B	50
	1	Fish raft	25	12	Seine boats	100
	1	Pile-driver	500	12	Seine-boat tenders	30
				4	Skiffs	20
Metlakahtla Industrial Co., Metlakahtla	2	Lighters	100	6	Seine boats	50
				7	Sailboats	100
				8	Dories	25
Baranoff Packing Co., Redfish Bay				4	Seine boats	75
North Pacific Trading and Packing Co., Klawak.	1	Scow	100	4	Seine boats	25
				5	Skiffs	25
Pacific Steam Whaling Co., Hunter Bay	4	Lighters	100	15	Seine boats	50
	2	Fish scows	50	3	Skiffs	25
	1	Pile-driver	800			

[1] F. B.=flat bottom.

Boat equipment, 1899.

Name of company and location of cannery.	Unrigged vessels.			Boats, etc.		
	No.	Description.	Value each.	No.	Description.	Value each.
Arctic Packing Co. (A. P. A.) Nushagak Bay.	18	Lighters	$600	60	Columbia River, gill-net boats.	$200
Alaska Packing Co. (A. P. A.) Nushagak Bay.						
Bristol Bay Canning Co. (A. P. A.) Nushagak Bay.	2	Pile-drivers	1,200	25	Skiffs	30
Pacific Steam Whaling Co., Nushagak Bay.	4	Lighters	300	15	Columbia River boats	200
				4	Skiffs	30
Alaska Fishermen's Packing Co., Nushagak Bay.	3	do	700	17	Columbia River boats	200
				3	Skiffs	30
Point Roberts Packing Co. (A. P. A.), Kvichak Bay.	7	do	800	30	Gill-net boats, F. B.	100
	6	Trap scows	100	10	Skiffs	30
	2	Pile-drivers	1,500			
Arctic Packing Co. (A. P. A.), Naknek River.	7	Lighters	800	24	Gill-nets boats, F. B.	85
	1	Pile-driver	1,200	10	Skiffs	40
Naknek Packing Co., Naknek River	8	Lighters	600	25	Gill-net boats, F. B	100
				5	Skiffs	25
Ugashik Fishing Station (A. P. A.), Ugashik River.	9	do	800	24	Columbia River boats	200
	1	Pile-driver	1,500	10	Skiffs	25
Chignik Bay Co. (A. P. A.), Chignik Lagoon.	2	Sail lighters	1,500	3	Seine boats, F. B.	100
	1	do	750	7	Columbia River boats	200
	12	Trap scows	250	8	Gill-net boats, F. B	100
	3	Pile-drivers	750	15	Skiffs	25
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	4	Lighters	400	3	Seine boats	75
	1	Sail scow	800	10	Columbia River boats	200
	1	do	200	3	Gill-net boats, F. B.	100
	10	Trap scows	60	10	Skiffs	25
	3	Pile-drivers	1,000			
Hume Bros. & Hume, Anchorage Bay, Chignik.	13	Lighters	140	2	Seine boats	70
	1	Sail scow	600	8	Columbia River boats	200
	1	do	300	10	Gill-net boats, F. B	100
	2	Pile-drivers	1,050	14	Skiffs	25
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.	1	Cargo lighter	500	6	Seine boats	60
	2	Fish lighters	250	1	Otter boat	100
	2	Fish scows	100	18	Dories	30
	1	Hand pile-driver	100	3	Skiffs	15
Karluk Packing Co. (A. P. A.) Karluk and Uganuk Bay.						
Alaska Improvement Co. (A. P. A.) Karluk and Uganuk Bay.	9	Lighters	500	20	Seine boats, F. B	150
Hume-Aleutian Packing Co. (A. P. A.) Karluk and Uganuk Bay.	13	Fish scows	150	33	Dories	25
				3	Launch tenders	90
	1	Hatchery scow	150	6	Hatchery cars	30
Uganuk Fishing Station (A. P. A.) Karluk and Uganuk Bay.						
Pacific Steam Whaling Co., Uyak Bay	5	Lighters	450	12	Seine boats, F. B	70
	1	Pile-driver	1,000	3	Sailboats	90
				10	Dories	30
Hume Bros. & Hume, Uyak Bay	4	Lighters	400	10	Seine boats	120
	1	Pile-driver	1,000	1	Whitehall boat	75
				17	Dories	20
				2	Skiffs	25
Pacific Steam Whaling Company, Kenai	7	Lighters	350	1	Seine boat	100
	2	Pile-drivers	1,500	20	Gill-net boats, F. B.	40
				3	Skiffs	25
Arctic Fishing Co. (A. P. A.), Kussilof River	3	Sail lighters	450	15	Gill-net boats, F. B.	40
	5	Trap scows	50	4	Skiffs	30
	2	Pile-drivers	1,500			
Pacific Packing Co. (A. P. A.), Odiak	2	Lighters	400	2	Seine boats	200
	3	Scows	400	33	Columbia River boats	200
				6	Skiffs	25
Pacific Steam Whaling Co., Orca	4	House scows	400	2	Seine boats	200
	1	Pile-driver	200	30	Columbia River boats	200
				8	Skiffs	25
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	3	Lighters	1,100	50	Columbia River boats	200
	1	Pile-driver	1,000	3	Skiffs	25
				7	Seine boats	60
Glacier Packing Co. (A. P. A.), Point Highfield.	2	Lighters	600	14	Columbia River boats	200
				8	Old river association	25
				5	Skiffs	25
Thlinket Packing Co., Gerard Point				10	Gill-net boats, F. B.	65
				3	Seine boats	50
				3	Skiffs	20
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.	2	Cargo lighters	150	25	Seine boats	50
	20	Fish lighters	75	1	Whitehall boat	50
				12	Skiffs	20
Boston Fishing and Trading Co., Yes Bay	5	Lighters	50	4	Seine boats	50
				6	Skiffs	25
Quadra Packing Co., Mink Arm, Boca de Quadra.	2	House scows	75	12	Gill-net boats, F. B.	50
	1	Fish raft	25	12	Seine boats	100
	1	Pile-driver	500	12	Seine-boat tenders	30
				4	Skiffs	20
				6	Seine boats	50
Metlakahtla Industrial Co., Metlakahtla	2	Lighters	100	6	Sailboats	100
				9	Dories	25
North Pacific Trading and Packing Co., Klawak.	1	Scow	100	4	Seine boats	25
				5	Skiffs	25
Pacific Steam Whaling Co., Hunter Bay	4	Lighters	100	15	Seine boats	50
	2	Fish scows	50	3	Skiffs	25
	1	Pile-driver	800			

Boat equipment, 1900.

Name of company and location of cannery.	Unrigged vessels.			Boats, etc.		
	No.	Description.	Value, each.	No.	Description.	Value, each.
Arctic Packing Co (A. P. A.), Nushagak Bay.	18	Lighters	$600	80	Columbia River gill-net boats.	$200
Alaska Packing Co (A. P. A.), Nushagak Bay.	2	Pile-drivers	1,200	25	Skiffs	30
Bristol Bay Canning Co. (A. P. A.), Nushagak Bay.				25	Columbia River boats	200
				4	Skiffs	30
Pacific Steam Whaling Co., Nushagak Bay	6	Lighters	300	17	Columbia River boats	200
Alaska Fishermen's Packing Co., Nushagak Bay.	4	do	700	3	Skiffs	30
Point Roberts Packing Co. (A. P. A.), Kvichak Bay.	7	do	800	50	Gill-net boats, F. B	100
Kvichak Packing Co (A. P. A.), Kvichak Bay.	6	Trap scows	100	10	Skiffs	30
	2	Pile-drivers	1,200			
Arctic Packing Co. (A. P. A.), Naknek River.	8	Lighters	800	34	Gill-net boats, F. B	100
	1	Pile-driver	1,200	10	Skiffs	40
Naknek Packing Co., Naknek River	7	Lighters	600	28	Gill-net boats, F. B	100
				5	Skiffs	25
Egegak Packing Co. (A. P. A.), Egegak River.	5	do	200	19	Gill-net boats, F. B	100
	1	Pile-driver	1,500	7	Skiffs	30
Ugashik Fishing Station (A. P. A.), Ugashik River.	9	Lighters	800	30	Columbia River boats	200
	1	Pile-driver	1,500	10	Skiffs	25
Bristol Packing Co., Ugashik River	1	Lighter	250	7	Gill-net boats	100
				1	Skiff	25
Chignik Bay Co. (A. P. A.), Chignik Lagoon.	2	Schooner lighters	1,500	3	Seine boats, F. B	100
	1	Sloop lighter	750	7	Columbia River boats	200
	12	Trap scows	250	8	Gill-net boats, F. B	100
	3	Pile-drivers	750	15	Skiffs	25
Pacific Steam Whaling Co., Anchorage Bay, Chignik.	4	Lighters	400	3	Seine boats	75
	1	Sail scow	800	9	Columbia River boats	200
	1	do	200	3	Gill-net boats, F. B	100
	10	Trap scows	60	10	Skiffs	25
	3	Pile-drivers	1,000			
Hume Bros. & Hume, Anchorage Bay, Chignik.	13	Lighters	140	2	Seine boats	70
	1	Sail scow	600	8	Columbia River boats	200
	1	do	300	10	Gill-net boats, F. B	100
	2	Pile-drivers	1,050	14	Skiffs	25
Arctic Packing Co. (A. P. A.), Olga Bay, Alitak.	1	Cargo lighter	500	6	Seine boats, F. B	60
	2	Fish lighters	250	1	Otter boat	100
	2	Fish scows	100	18	Dories	30
	1	Hand pile-driver	100	3	Skiffs	15
Karluk Packing Co (A. P. A.) Karluk and Uganuk Bay.	9	Lighters	500	20	Seine boats, F. B	150
Alaska Improvement Co. (A. P. A.) Karluk and Uganuk Bay.	17	Fish scows	150	33	Dories	25
Uganuk Fishing Station. (A. P. A.) Karluk and Uganuk Bay.	1	Hatchery scow	150	3	Launch tenders	90
				6	Hatchery cars	30
Pacific Steam Whaling Co., Uyak Bay	5	Lighters	450	15	Seine boats, F. B	70
	1	Pile-driver	1,000	3	Sail boats	90
				13	Dories	30
Hume Bros. & Hume, Uyak Bay	4	Lighters	400	12	Seine boats	120
	1	Pile-driver	1,000	1	Whitehall boat	75
				20	Dories and skiffs	20
Alaska Salmon Association, Chuitna River.	2	Lighters	150	20	Gill-net boats, F. B	40
	4	Scows	250	5	Skiffs	30
	1	Lighter	50	1	Yawl	40
	1	Pile-driver	1,150			
Pacific Steam Whaling Co., Kenai	7	Lighters	350	1	Seine boat	100
	2	Pile-drivers	1,500	20	Gill-net boats, F. B	40
				3	Skiffs	25
Arctic Fishing Co. (A. P. A.), Kussilof River.	3	Sail lighters	450	2	Columbia River boats	200
	7	Trap scows	50	20	Gill-net boats, F. B	40
	2	Pile-drivers	1,500	6	Skiffs	30
Pacific Packing Co. (A. P. A.), Odiak	2	Lighters	400	2	Seine boats	200
	3	House scows	400	33	Columbia River boats	200
				6	Skiffs	25
Pacific Steam Whaling Co., Orca	5	House scows	400	2	Seine boats	200
	1	Pile-driver	200	30	Columbia River boats	200
				8	Skiffs	25
Western Fisheries Co., Dundas Bay	1	Lighter	250	5	Seine boats	75
				2	Columbia River boats	100
				4	Gill-net boats	50
				2	Dories and skiffs	60
Pyramid Harbor Packing Co. (A. P. A.), Pyramid Harbor.	3	Lighters	400	56	Columbia River boats	200
	1	Pile-driver	1,000	3	Skiffs	25
Chilkoot Packing Co., Chilkoot Inlet				2	Columbia River boats	90
				1	Skiff	25
Taku Packing Co., Taku Inlet	2	Lighters	225	15	Gill-net boats	60
	1	Fish scow	150	2	Dories	25
				3	Seine boats	50
Taku Fishing Co., Port Snettisham	1	Lighter	500	3	Columbia River boats	150
				9	Gill-net boats, F. B	50
				12	Seine boats	100
Icy Strait Packing Co., Petersburg, Wrangell Narrows.	1	Cargo lighter	850	12	Gill-net boats, F. B	50
	1	Pile-driver	500	12	Seine-boat tenders	35
				4	Skiffs	20
Royer-Warnock Packing Co., Beecher Pass.	1	Scow	30	1	Seine boat	30
				1	Dory	10

Boat equipment, 1900—Continued.

Name of company and location of cannery.	Unrigged vessels.			Boats, etc.		
	No.	Description.	Value, each.	No.	Description.	Value, each.
Glacier Packing Co. (A. P. A.), Point Highfield.	2	Lighters	$600	7	Seine boats	$50
				14	Columbia River boats	200
				8	Old river boats	25
				5	Skiffs	25
Thlinket Packing Co., Gerard Point	1	House scow	400	6	Seine boats	60
	1	Fish scow	100	10	Columbia River boats	200
				6	Gill-net boats, F. B	60
				2	Whitehall boats	85
				3	Skiffs	20
Fidalgo Island Canning Co., Ketchikan	2	Lighters	225	12	Seine boats	70
	3	....do	75	8	Dories and skiffs	30
	3	Scows	20			
Alaska Salmon Packing and Fur Co. (A. P. A.), Loring.	2	Cargo lighters	150	42	Seine boats	50
	20	Fish lighters	75	1	Whitehall boat	50
				12	Skiffs	20
Boston Fishing and Trading Co., Yes Bay	5	Lighters	50	4	Seine boats	50
				6	Skiffs	25
Quadra Packing Co., Mink Arm, Boca de Quadra.	1	House scow	75	8	Seine boats	100
				9	Skiffs	30
Metlakahtla Industrial Co., Metlakahtla	2	Lighters	100	7	Seine boats	50
				6	Sailboats	100
				10	Dories	25
North Pacific Trading and Packing Co., Klawak.	1	Scow	100	11	Seine boats	80
				5	Skiffs	25
Pacific Steam Whaling Co., Hunter Bay	2	Lighters	100	22	Seine boats	50
	2	Fish scows	50	3	Skiffs	25
	1	Pile-driver	800			

MOUTH OF KARLUK RIVER WHERE IT EMPTIES INTO KARLUK LAGOON.

CALLBREATH'S HATCHERY, McHENRY INLET, ETOLIN ISLAND

THE KARLUK HATCHERY.

By Harry Clifford Fassett,
U. S. Fish Commission.

The following notes concerning the salmon hatchery maintained by the Alaska Packers Association near Karluk, Kadiak Island, Alaska, are based upon an inspection made in accordance with instructions of Captain Moser August 8, 1900.

The plant is a model one. It is located on the southern shore, at the eastern end of the Karluk Lagoon, near the outlet of Karluk River, where a streamlet, called by the hatchery people Shasta Creek, enters the lagoon from the hills to the southward. From the rising ground immediately back of the hatchery Karluk Head, 3 miles west (magnetic), may be seen over the intervening low points, with the cannery buildings of Karluk Spit showing to the right of it. Here ground was broken for the hatchery May 28, 1896, and on August 29, the same year, construction work was so far advanced that stripping was begun. The actual cost of the present plant is said to be fully $20,000, and the annual expenditure about $10,000 for maintenance, repairs, and labor. Considering the extent of the establishment, the rate of wages necessarily demanded from its isolation, the long period of incubation, and expensive methods of securing stock fish, this hardly seems excessive.

In 1897 a party from this vessel visited this hatchery, the results of whose observations are contained in Captain Moser's report upon "Alaska Salmon and Salmon Fisheries, 1897," pages 155–157, to which attention is invited.

Since then the establishment has been considerably improved, without, however, increasing the egg capacity of the hatching-house; in fact, this has been reduced by one trough, which was removed to make room for the hot-water drum of the heating system. A number of new ripening ponds have been made, the rearing or nursery pond enlarged, and the original ponds remodeled. In the main building the dining room and kitchen have been moved upstairs, an additional room built out in front, the basement enlarged and partly cemented, heating system enlarged and improved, and an electric-light plant installed. The latter has a capacity of about 40 lights, with 25 outlets at present, and the power is generated by a small Pelton wheel fed by a 6-inch pipe under a head of about 60 feet.

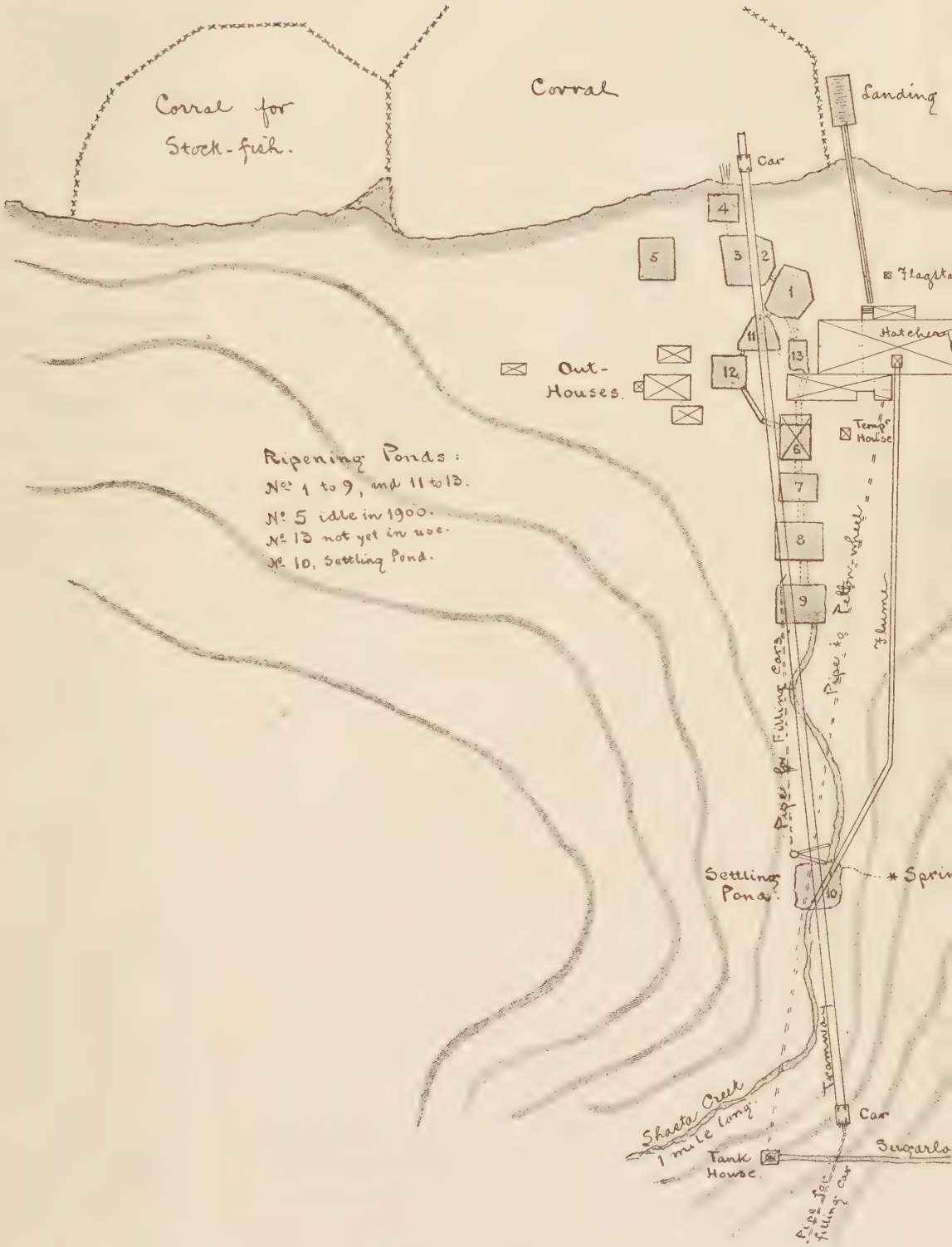
The main building, 32 feet by 100 feet, faces to the northward (see sketch). Immediately west of it are a tramway and line of ponds, the latter extending down the slope along the original bed of Shasta Creek northward to the beach. Abutting the eastern end of the hatching-house is a covered pond known as the "reservoir," and beyond, in the same direction, a narrow ditch leads to the nursery pond. A plank walk extends from the hatchery steps across the narrow beach flat to a short wooden pier which ends at a condemned lighter weighted with stones, forming the landing place. Immediately westward of the landing are the corrals. On either flank of

the main building are small outhouses, sheds, etc., and close to the rear entrance is a small shed where the thermometers are kept. South of the hatching-house, at the head of a small ravine and on the edge of a narrow undulating terrace in the hills, the present sources of the water supply are brought together.

Shasta Creek is a tiny rill draining the low hills to the southward and westward, and has an average volume of about 10 miner's inches of clear water of excellent quality; it is about a mile in length from its source to the lagoon. "The Ditch" comes in from the eastward, and carries the waters of a small creek flowing down the side of a mountain, about a mile distant, which is locally known as Sugarloaf Peak. The bed of the ditch is now well settled and ballasted, smooth, free from sudden drops, falls, or riffles, of a very gradual pitch, and carries an average of between 25 and 30 miner's inches of clear, colorless water of excellent quality; it is about 1½ miles long. At the end of the ditch its waters are received by a shed-covered tank (the "tank house"), in the bottom of which is the connection to a line of 6-inch piping leading to the hatchery below; a branch of this system supplies the Pelton wheel. The escape or waste from the tank-house finds its way into Shasta Creek, close by. From this point to the lagoon beach is about 200 yards in a straight line.

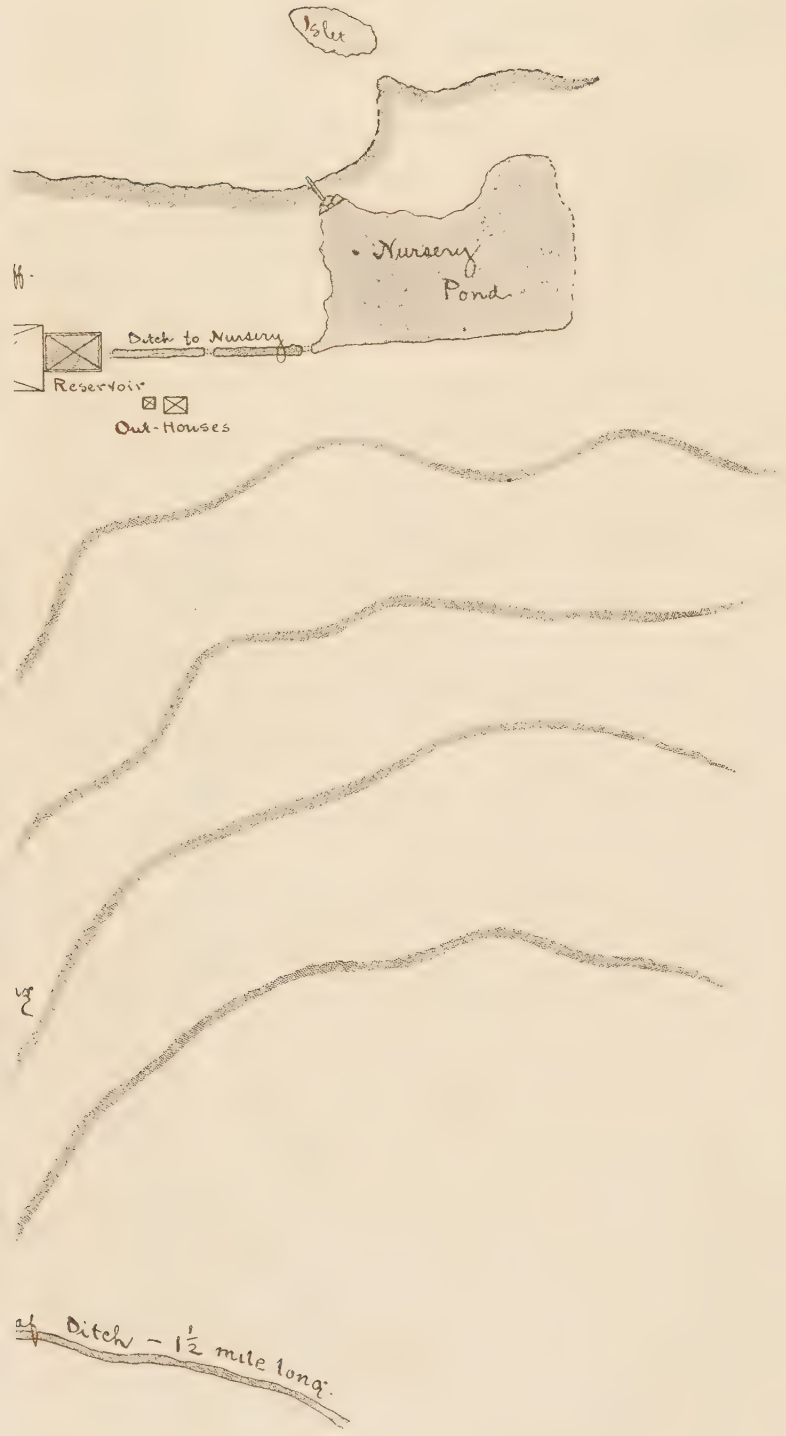
The waters of Shasta Creek are first tapped by a line of iron pipe a short distance above the tank-house; this pipe is used for filling a car at the upper end of the gravity tramway, which is close to the tank-house. The creek passes to northward and westward of the tank-house and plunges down the small ravine previously mentioned, and about one-fourth the distance to the beach ends in the highest pond. From this pond, called No. 10, or the "settling" pond, a wooden flume carries part of the water into the upper part of the hatching-house, while the overflow escapes via the old creek bed to the next pond below. The settling-pond also receives, in its northeastern corner, the waters of a small spring running the year round; this corner of the pond never freezes. The escape of pond No. 10 is tapped to supply another short line of piping which leads northward to the next pond, where it is used in connection with the tramway. This pond, No. 9, is the upper ripening pond and located about midway between the tank-house and the beach. In close order, terraced northward down the gentle slope, are ripening-ponds No. 8, No. 7, and No. 6, the latter housed in. From No. 6 the waste water escapes through open ponds No. 12 and No. 11 into No. 1, and, by another outlet, to pond No. 13 and thence to No. 1. From pond No. 1 the water passes in turn through No. 2, No. 3, and No. 4, and thence into the East Corral. Pond No. 5 is out of the direct line of the system, and was not in use in 1900. No. 13 was built this season, but had not been placed in use at the time of my visit. None of the water used in the ripening-ponds goes into the hatching-house.

The supply for the hatching-house is first by the pipe-line which leads from the ditch (via the tank-house), and next by flume from the settling-pond. The settling-pond is quite deep, much more so than any other, and receives its feed so gently as not to stir the sediment from the bottom and roil the water. As its name implies, its function is to allow the small débris carried by the creek to settle before passing on into the flume or to the lower ponds. The discharge, whether from the pipe line or the flume passes into a filter in the upper story of the hatching-house, thence into a tank, from which it is piped to the troughs. The waste water discharges into the



SKETCH PLAN OF SALMON-HATCHING PLANT, OPERATED BY ALASKA PACKERS ASSOCIATIO

Scale and dimensions arbitrary.



AT SHASTA CREEK, KARLUK LAGOON, KADIAK ISLAND.

reservoir, and from it escapes through the narrow ditch already mentioned into the nursery, or rearing-pond, whence it passes through a short flume into the lagoon.

As far as the circumstances have permitted, the ripening-ponds have been dug rectangular in shape, and as opportunity affords they are walled up with rubble and cement. The floors are of broken rock and gravel, but it is the intention to cover these with cement also as soon as time permits. The fish do not ripen well in dirty water, and their frequent violent movements stir up any mud which may be on the bottom or in the interstices of the sides. The same movements of the fish tend to keep in suspension any slime or other foreign material, which thus passes out through the wasteway, and this is so slight where the ponds are walled solidly that no deleterious effects are apparent, even after the water has passed through several ponds full of ripening fish.

All the upper ponds have sufficient fall between one and another for excellent aeration, a most important consideration where many fish are impounded. Covered pond No. 6 has the best arrangement for aeration, which may be described as follows: The feed water passes through a wooden trough suspended horizontally over the pond and extending longitudinally toward the center. The bottom of the trough is about 4 feet above the surface of the pond, and is pierced by numerous auger holes, through which the water falls in tiny streams. Besides giving perfect aeration this method distributes the supply over such a large area that the impounded fish are less excited than is the case where the same volume enters in a single stream; they keep more quiet, ripen more quickly, and if they do leap do not strike against anything which will bruise them, but merely fall back into the pond again. This arrangement will be extended to the other ponds whose relative elevations will admit of it, as opportunity offers. The low ponds, No. 3, No. 4, and No. 5, have not given satisfaction, and this is due probably to lack of adequate aeration. No. 2, however, though on practically the same level as No. 3, is an excellent pond, but its superiority is thought to be due to being tightly walled, and consequently cleaner than its mate. No. 5 is expected to prove satisfactory after it has been cemented.

When a pond is to be gone over for ripe fish the water is lowered to a depth of about 21 inches, or knee-deep, the waste gates being arranged to let it fall to that depth, but no less, for fear of smothering the fish. A panel of slat fencing is then lowered into the water at one end and pushed slowly toward the opposite side of the pond, the spawn-takers wading behind it. The fish are carefully dipped up, examined, and if found ripe for spawning placed in a floating car, made of slats, for future attention; if still green they are freed in the pond behind the fence. This method of handling the impounded fish has proven the best with the delicately organized red salmon, and explains the importance of having the ponds of a regular shape; thus every fish can be handled and every ripe one secured with the least injury. After the operation has been completed the fence is removed and the live-car of ripe fish towed gently alongside the stripping platform, of which there is one at each ripening-pond.

Stock fish for the hatchery are secured by seining crews working under the orders of the superintendent of the association's canneries at Karluk Spit. These crews are composed of natives who are borne on the cannery rolls. The principal seining-ground is on the northern shore of the lagoon, opposite the hatchery, from

the mouth of the river downstream to a rocky point three-quarters of a mile westward. After a seine haul is made the live fish are bailed into two live-cars, composed of old dories and skiffs with square ports cut between each frame, over which galvanized wire netting of 1½-inch mesh is stretched. Two men in another boat then tow the live-cars across to the corrals, where the fish are tallied out. It has been observed that it is much better to impound the stock fish, especially early in the season, in a large inclosure. When first taken they are exceedingly restless, chafing under restraint, and if closely confined soon become scarred and bruised, causing fungoid growths to appear quickly. The nearer the adult fish approaches maturity the more quiet it becomes.

The corrals are two in number, and cover an area of about 3 acres, the East Corral being about twice as large as the West. At high high water there are about 10 feet of water at the outer edge of the corrals and at the inshore edge about 2 or 3 feet; the rise and fall here, extreme range, is about 5 feet. The corral fences are composed of wire and cotton netting, the latter above, stretched between piles and stands of old iron pipe. Everything but the piling is removed after spawn-taking ceases for the season; the piles are secured after the ice loosens them in the winter and are then hauled ashore.

The mortality of the fish seined is greatest in the corrals, as they receive the roughest treatment in the process of first capture. In discharging the live-cars into the East Corral the cars are brought bodily inside the inclosure through a movable panel, after which the fish are dumped out. At the West Corral the cars are towed alongside an opening above the water line and the fish dipped over from the outside.

In taking fish from the corrals for the ripening ponds the seine is again employed, the one used being about 12 fathoms in length. This is hauled into the shoal water off the lower end of the tramway; four large floating cribs of slats are then secured to the cork line outside, two being for bucks and two for females. The fish are then picked out of the net as tenderly as possible and examined; if too green they are passed back into the corral. When the cribs have been filled with a sufficient number they are hauled alongside the tramway and the fish dipped out into a car, previously filled with fresh water, in which they are transported to the pond prepared for them and there left to ripen. When fish which are quite or nearly ripe are secured they are taken care of separately. A number of fish nearly ripe are often taken with the incoming tide from the No. 4 pond, finding their way through the wasteway as the water rises.

The tramway is about 200 yards long and leads from the hill near the tank-house in a straight line, crossing several ponds en route, to the lagoon beach near the eastern end of the East Corral. It is a gravity road, built of plank, and its chief purpose is the hauling of stock fish to the upper ripening-ponds. Two strongly built cars, connected by a manila cable, are used, one at each end of the line. After the lower car, which is much smaller, has been filled with water and live fish the larger one at the upper end is loaded, also with water, its greater weight hauling the lower car to the upper ripening-pond, No. 9, midway of the tramway, where the two cars meet. Intermediate stops, as required, are made at the lower ponds. After discharging the fish from the lower car enough water is drawn from the larger one to change the preponderance of weight, and the cars then resume their original

positions at either end of the line. This method of transportation is an old one, much used by mining men.

As already indicated, there is a spawning platform adjacent to each ripening pond, and as but one of these is covered the spawn-taking is conducted almost wholly in the open air. In 1900 no spawning was done at one of the ponds, it being used for the bucks alone. The methods employed on the spawning platform and in the hatching-house were originally those followed at the salmon stations of the United States Fish Commission, and more especially at the quinnat hatchery at Baird, Cal., the changes inaugurated being the result of subsequent experience in the handling of the more delicate red salmon.

Spawning is done by hand exclusively; strait-jackets are not necessary with these small fish. One hundred and fifty is counted a big day's stripping, though as high as 224 have been handled. The spawn pans are circular, 9 inches in diameter at the top, beveled to 7 inches across the bottom, and 3½ inches deep; a thin coat of asphaltum lacquer prevents their rusting and renders them easily cleansed. Two methods are employed in the taking of spawn; the first method, which is considered the better, is the "dry," the mixing of eggs and milt being done with the fingers. The eggs are not washed, but are placed directly in the baskets within two or three minutes after stripping. The second method is similar, except that after the two or three minutes have elapsed a little water is added; they are then allowed to stand until adhesion ceases and basketed without washing. When circumstances permit, the milt of two bucks is used to fecundate the eggs of one female.

Twenty-five females are reckoned to a full basket, which, at the estimated average of 3,000 good eggs per fish, gives a total capacity of 75,000 eggs per basket. The diameter of the redfish egg ranges between 0.10 and 0.31 inch, with an average of about 0.22 inch. It is much lighter in color than the egg of the quinnat salmon, and has a very delicate appearance. At Karluk it has been found that redfish run from 2,500 to 4,500 eggs, in rare instances 5,000, and that a fair average will be about 3,700; but there is, of course, a certain unavoidable loss in the spawning operation, and frequently a large number of eggs come from the fish dead; 3,000, therefore, is a fair average.

A glance at the sketch plan of the hatching-house will give a fair idea of its interior floor arrangement. There are 12 sets, or sections, of 4 troughs each, and 1 set of 3, making a total of 51 hatching-troughs. These troughs all measure 14 feet in length, 16 inches in width, and 7 inches in depth inside. They are built of clean-grained redwood, all sides surfaced, and all 2 inches thick. In making the joints a thick coating of asphaltum tar is spread over the parts to be joined, with an even layer of cotton wadding as calking material. The completed trough receives a coat of refined tar and two coats of asphaltum varnish. Built in this manner and properly supported the troughs will not warp or spring, and there has never been the slightest difficulty from leaks. This is an important consideration in the hatching-house. Not only do leaky troughs add greatly to the waste of water and keep the employees uneasy concerning the amount of water getting to the eggs, but the unavoidable jarring and other shocks connected with the necessary repairs are frequently fatal to a large number of eggs. A dry trough makes a dry hatching-house, and in a dry house only will the best efficiency of the egg-picking crew obtain. Where one has to stand on a wet

cold floor all day in a chilly, drafty room, at work requiring deftness of touch and close attention, considerable endurance is needed physically, and it is by no means unusual at hatcheries to have to call in new help while the regular hatching-house force are suffering from colds, rheumatic attacks, etc. In a dry, well-lighted hatchery the interest of the fish-culturist does not wane from physical causes, and the eggs and fry consequently receive the benefit of these comforting features. Nearly anyone will hurry through with his allotted number of baskets in a sloppy, cheerless, and chilly barn, slighting the work in spite of himself, and yet the same person would almost always give intelligent attention to a task which he finds extremely interesting under physically comfortable conditions.

Besides the superintendent the permanent force of the station numbers 6, including a cook. All the regular work of fish-culture is done by this force, and a large part of the building and permanent improvements is executed by the same persons. When additional labor is necessary a request is made upon the superintendent of the association's canneries at Karluk Spit.

A furnace in the basement of the main building, directly under the hatching-house, heats the water for a system of piping used solely for artificial heating. A set of coils is arranged directly under each section of troughs, and there is also a system of piping on the bottom of the reservoir pond. When artificial heat is employed in forcing the hatching of the eggs the steam boiler is placed in use to drive the pumps. The latter draw the water from the reservoir pond, where it has been warmed, discharging it into the filter upstairs. It will be remembered that the waste of the hatching-house troughs escapes to the reservoir pond, but before using this warm water again filtering and aerating are necessary. Just enough new water is added to freshen the supply without much reducing the temperature, and very little is needed. If the water were not used over and over again in this manner it would be almost impossible and entirely impracticable to heat it sufficiently during the cold winter months, but the system of aerating and freshening is so well controlled that the feed water remains perfectly good after repeated use.

The feed water of the hatching-house, whether received from the flume or pipe line, is thoroughly filtered before passing into the troughs. Much of the coarser débris, such as straws, twigs, leaves, etc., is cleared from the water at the settling-pond and tank-house, and coarse-mesh wire screens in the lower end of the flume are also employed. Referring to the sketch it will be seen that the filter is simply a set of screens of varying degrees of fineness, arranged in a long wooden trough. The water falls from the flume or pipe upon the upper end of the top screen, which is a long board pierced with numerous auger holes. These holes increase in diameter as the farther end is approached, and the board is given sufficient pitch to cause the water to run down and cover it all, the function of the board being primarily to distribute and incidentally to aërate.

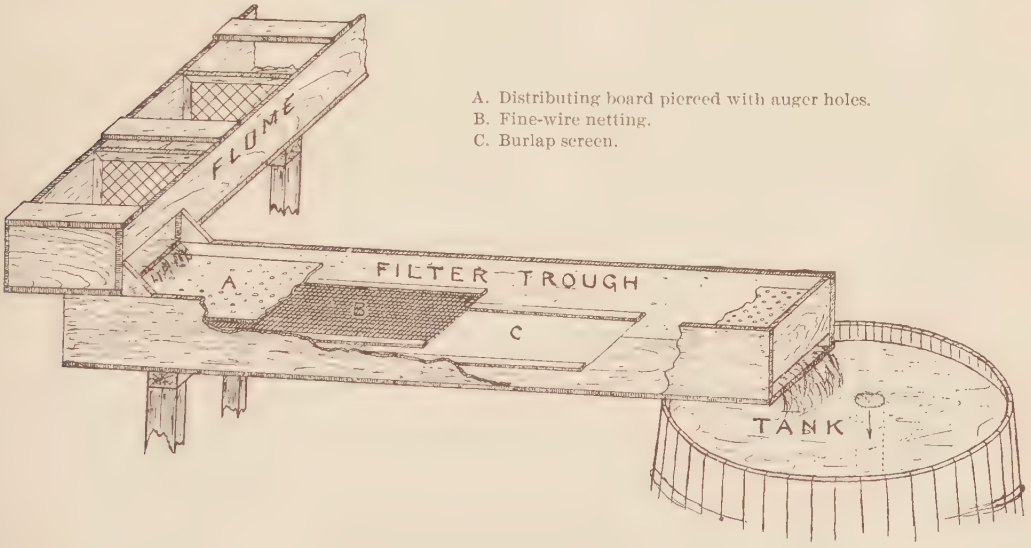
Falling next through a fine-mesh screen of wire netting the water is received in very fine spray-like condition by the last and lowest tray or screen. This is made of burlap, tightly stretched over a strong, light wooden frame, and has proven a most excellent filtering material. After it has become thoroughly soaked the jute or hemp of which it is composed swells closely and tightly, efficiently cleansing the

KARLUK HATCHERY, SHOWING CORRALS, AND IN DISTANCE EEL-GRASS BED.

A RIPENING POND, KARLUK HATCHERY.

water of very fine particles. With the more than usually excellent quality of water here, and its lack of foreign material, the above arrangement is found to meet the requirements of filtering. Where a refinement of this feature is necessary, however, it will readily be seen that there is no limit to the extension of the number or fineness of the screens.

The burlap used is of a slightly superior quality to the ordinary bagging, and in addition to its efficiency has its cheapness to recommend it. When stretched on frames it should be evenly secured, as its shrinking tendencies cause it to tear where the strains are unequal. The frames should be small and in sufficient number to allow of at least two changes in addition to the set in the filter trough. This is necessary, as the burlap will rot if left continuously in water, but if removed and thoroughly dried every ten days or two weeks the screens will last a long time. Four or 5 feet is a good length for the frames. When using more than one set of burlap or cloth screens care should be observed that the joints between the ends of the frames do not occur directly below each other; they should be staggered—that is, designed to occur at different intervals—the reason for which is plain.



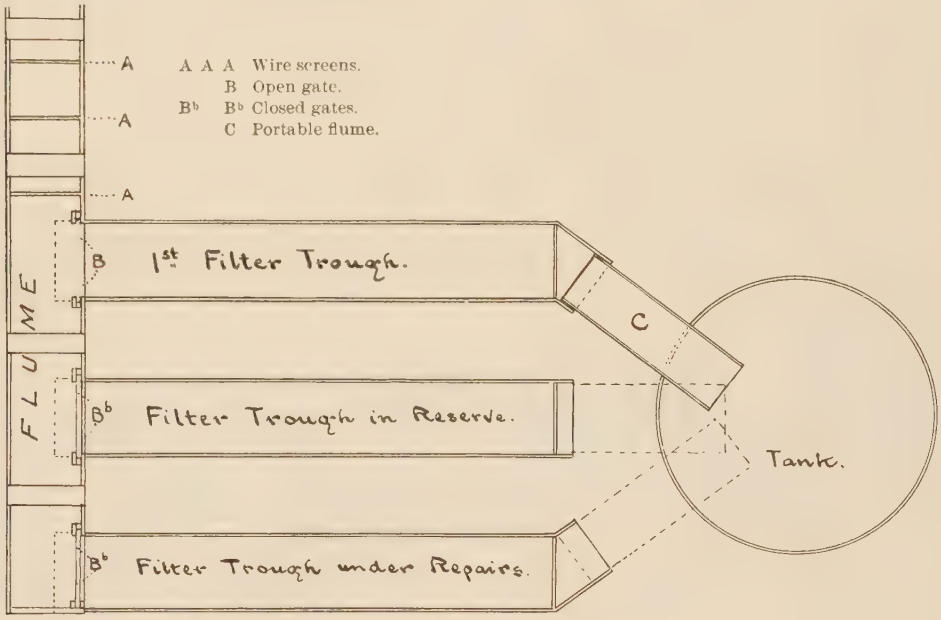
Perspective sketch of Richardson filter.

While there is as yet but one filter trough in the hatchery at Karluk, the superintendent, Mr. James A. Richardson, is a strong advocate of three, arranged somewhat as shown in the sketch. This will allow one to be in use, one in reserve, and the third under whatever repairs it may require. With a long hatching season and a long nursing period little opportunity is offered to overhaul so important an adjunct as the filter if to do so requires that it be placed temporarily out of commission. As the expense is slight, such an arrangement has much to recommend it.

It is stated that fungus has never caused trouble at the Karluk hatchery under the present management; at the old station, less than a mile westward on the same side of the lagoon, much difficulty was experienced from this cause. It is due to dirty water, unclean troughs and baskets, and careless and insufficient picking of the

eggs; it is likewise sometimes caused by too sluggish a current in the troughs, too small a supply of feed water, lack of aeration, or from using the water over too many times. In many cases fungus will not occur if troughs and baskets are kept clean and the water is properly filtered.

The troughs are designed to hold five baskets each, allowing for the necessary space between each for division plates, as well as the compartments at each end for receiving and aerating and discharging the flow of water. The aerators are of tin of the usual pattern and distribute the water well; at the opposite end of the trough is the usual arrangement of drainage plugs. The division plates are arranged according to the so-called Williamson system; that is, the first plate rests on the bottom of the trough with the water flowing over it, and, a short distance beyond, the second plate comes flush with the surface, but allows the flow to pass under it, the most



Plan of Richardson filter troughs.

approved method of conducting feed water through salmon eggs. Instead of rigid plates sliding in grooves at set intervals, division plates of light galvanized sheet iron, thickly asphalted, are used; these are half an inch longer than the width of the trough and are snapped or sprung in at any point desired. A drop of about $1\frac{1}{2}$ inches is given each trough, and the water is used four times before discharging into the waste trough.

The waste trough is a continuous wooden box, built of heavy redwood boards, which passes under the lower, or fourth, trough of each set and carries off the entire waste of the hatching-house; it passes around the south wall and part of the east wall and thence into the reservoir, where it discharges.

The baskets are 24 inches long, 15 inches wide, and $6\frac{1}{2}$ inches deep, inside measurement, made of galvanized-wire netting secured to a single wooden frame. The

frames are of clear sugar pine and redwood, 1½ inches wide by five-eighths inch thick. The netting is five-eighths inch in the length of the mesh and 6 meshes to the inch, which is found the best size for redfish eggs; netting with 5½ meshes per inch has been used, but this is a trifle large. Baskets with a single wooden frame around the top are found quite rigid enough and have a great advantage in the small space occupied by a large number when stored away, the absence of the lower frame admitting of very snug nesting.

While the capacity of each trough is 5 baskets, it is preferred to use not more than 4 per trough, reserving the fifth space for "fleeting" in cleaning. It has been found that redfish eggs require the cleanest of troughs and baskets, as well as the most careful handling. The troughs are therefore cleaned as frequently as circumstances will admit, never less than once a week, and as often as every other day when possible. Thus, by having the fifth space unoccupied the entire trough can be thoroughly scrubbed without lifting a single basket of eggs; all the baskets are moved one space toward the lower end of the trough and returned to their original positions one at a time as their respective spaces are cleaned. By fleeting in this manner jars are avoided and the eggs remain water-borne at all times—an especially essential desideratum during the tender period.

As previously mentioned, a full basket of redfish eggs is reckoned as containing 75,000. Thus, with 51 troughs equipped with 4 baskets each, or 204 baskets, the hatching-house capacity may be conservatively given as 15,300,000 eggs; and by crowding in 5 baskets to a trough, making a total of 255 for the house, the capacity can be increased to more than 19,000,000. These figures merely show the number of eggs which may be placed in the baskets at one time, or what the hatching-house will hold without using the baskets over again. Generally it does not follow that this is the capacity for the season, but unfortunately it does at Karluk. Here the period of incubation is so long that eggs taken at the very opening of the salmon run, say the latter part of May, will not be hatched out until the close of the season, late in September, after which but a trifling percentage of the spawn is taken. The number of eggs basketed prior to July 1 is also quite small, and the gain in capacity is therefore too trifling to be taken into consideration. Hence these figures may be accounted correct as they stand.

It is unfortunate that a full series of data is not available for an analysis of the period of incubation under the various prevailing conditions. Until this season (1900) the superintendent has been unable to keep complete records of anything beyond the merest outline of the season's work. A detailed record of temperatures and the duration of the various stages of incubation, representative of baskets of normal eggs taken at regular intervals during the stripping season, is being kept now, and it is believed this material will be available for study later. These observations will be carried on until the last of the fry shall have been planted. Such data, however, as could be obtained is herewith submitted, believing that much of it will be of interest and that possibly some of it may prove of value in the future.

In 1896 spawn-taking commenced on August 29 and was continued at intervals of two or three days until November 28, 3,200,000 eggs, in fair condition, being basketed during this time. Considering the diseased state of most of the stock fish secured, that this was the first season of operation, and that the plant was still in

a partially unfinished state, the result was deemed good. Impregnation by the methods at first employed was not always assured, and the losses were in consequence somewhat augmented.

After stripping began daily temperature observations of the hatchery water were recorded, from which the table below has been condensed. The highest temperature recorded during the summer (1896) was 48° F., and the lowest, during the following winter, 33° F.

Month and year.	Temperature of hatchery water.			Month and year.	Temperature of hatchery water.		
	Max.	Min.	Mean.		Max.	Min.	Mean.
	°	°	°		°	°	°
Sept., 1896	45	36	42.5	Jan., 1897	35	33	+34
Oct., 1896	40	35	39	Feb., 1897	35	33	+34
Nov., 1896	36	33	35.2	Mar., 1897	34	33	33.8
Dec., 1896	35	33	+34				

These figures represent the temperature of the feed water as it came from the creek under natural conditions. During part of the time the water in the hatching-troughs was warmed artificially and the temperature there was somewhat higher. Unfortunately no exact data of thermal conditions during the forcing or hastening process were kept, but it is stated that the temperature was slowly raised 10° or 12° above that then prevailing, and then kept at that point, about 46° to 48° F.

The temperature of the air outside of the hatchery for November and December, 1896, and January, February, and March, 1897, is summarized as follows:

Temperature.	Period.	
	Days.	*hrs.*
Between 10° below and zero	2	15
Between zero and 10° above	5	21
Between 10° and 20° above	21	7
Between 20° and 30° above	11	11
Between 30° and 40° above	71	4
Between 40° and 50° above	8	14

The eggs taken August 29, 1896, eyed in 60 days, with the water in the troughs ranging between 45° and 35° and the mean 40.5° F. These eggs hatched out in 165 days. The eggs taken September 16 eyed in 100 days, with the temperature ranging between 44° and 33° and the mean 36.2° F. These also hatched in 165 days, but during the last 42 days of the incubating period artificial heat was used. The eggs taken September 23 were eyed in 111 days, temperature ranging between 43° and 33° and mean 34.5° F. Artificial heat was employed to hasten development during a period of about six weeks at the latter end of this period.

In 1897 spawn-taking was carried on from August 19 to December 9, and 2,285 females were stripped. Less than 1 per cent of them were spawned in August, about 85 per cent in September, and 14 per cent in October, November, and December. From September 6 to 20, only 15 days, 65.5 per cent of the salmon were spawned. The greatest number spawned in one day was 224, on September 25.

Concerning the relative proportion of males to females taken and their mortality in the stock ponds, or corrals, the following note is of interest: Of 6,640 salmon

TRANSFERRING STOCK FISH TO CORRALS AT KARLUK HATCHERY, KADIAK ISLAND.

METHOD OF DRAWING OFF FRY FROM NURSERY POND, KARLUK HATCHERY, KADIAK ISLAND.

impounded in the river corral, 4,170 were males and 2,470 females. Of 3,292 dead salmon removed from the corral, representing the loss in the inclosure for the season, 1,998 were males and 1,294 females.

The amount of spawn placed in baskets during the 1897 season was not learned, but the superintendent stated that "fully 6,000,000 fry were 'turned out' from the eggs taken in 1897." To this should be added the amount of eggs lost in the hatchery troughs, say 20 per cent, and the loss from malformations, etc., say 6 to 10 per cent. It is estimated that about 5,000,000 fry were planted.

The facilities of the establishment had been much improved since the preceding year, spawn-taking was conducted under much better circumstances, and the experience gained may also be considered a material factor in this season's hatching-house results. It was observed that the fry hatched were more vigorous and healthy in appearance, though hatching more slowly. The eggs taken August 19 were *hatched* in 210 days; those taken October 7 and November 2 were 123 and 138 days, respectively, in simply *eyeing out!* No artificial heat was used in hastening the development of the ova that year—season 1897. Beyond the foregoing there are no data available concerning the hatching period, etc.

Preparations were being made at the time of my visit to increase the hatching-house capacity by 13 more troughs, to bring the total up to 64; to extend Sugarloaf Ditch so as to tap the waters of another stream farther to the eastward, a mile or more; to extend the nursery system, and to improve the present retaining or ripening ponds in the manner previously outlined.

The following shows the temperature recorded in the hatching-house feed water:

Month and year.	High.		Low.		Mean.	Month and year.	High.		Low.		Mean.
	Max.	Mean.	Min.	Mean.			Max.	Mean.	Min.	Mean.	
	°	°	°	°	°		°	°	°	°	°
Apr., 1897	37	−37	33	34.7	35.8	Nov., 1897	39	+36	33	35.1	35.5
May, 1897	47	43	34	37.7	40.3	Dec., 1897	39	36	33	35.3	35.6
June, 1897	50	47.7	40	42.5	45.1	Jan., 1898	36	34.8	33	34.3	34.5
Sept., 1897	52	46.3	37	42.8	44.5	Feb., 1898	36	34.6	33	34.2	34.4
Oct., 1897	45	39.1	33	37.7	38.9	Mar., 1898	39	36	33	34.6	35.3

The temperature of the air, dry bulb, outside the hatchery during the winter is summarized as follows, for November and December, 1897, and January, February, and March, 1898:

Temperature.	Period.
	Days. hrs.
Between 10° below and zero	0 2
Between zero and 10° above	12 13
Between 10° and 20° above	11 19
Between 20° and 30° above	31 22
Between 30° and 10° above	83 20
Between 40° and 50° above	10 20

The records for the spawning season of 1898 are again woefully incomplete. Some fish are reported as spawned in June, and from July 5 to November 30, 5,000,000 eggs were placed in baskets. Of the latter 80 per cent were taken prior to October 4; the remainder were obtained in gradually diminishing numbers until November 30.

No temperature records whatever are available, but the hatching periods were noted as per table below. The lack of thermal data is deplored, but is accounted for by the unavoidable absence of the regular superintendent the greater part of the time.

Eggs taken in 1898.	Hatched first.		Hatched last.		Mean hatching period.	Range in hatching.	Eggs taken in 1898.	Hatched first.		Hatched last.		Mean hatching period.	Range in hatching.
	Date.	Days.	Date.	Days.				Date.	Days.	Date.	Days.		
July 5..	Oct. 19, 1898	106					Sept. 9.	Feb. 14, 1899	158				
July 8..	Oct. 20, 1898	104	Nov. 20, 1898	135	120	31	Sept. 10.	Feb. 18, 1899	161	May 15, 1899	247	204	86
July 11..	Oct. 21, 1898	102					Sept. 12.	Feb. 19–20, '99	160	May 15, 1899	245	203	85
July 15..	Nov. 6, 1898	114					Sept. 14.	Feb. 26, 1899	165	May 22, 1899	250	208	85
July 17..	Nov. 7, 1898	113	Dec. 6, 1898	148	132	35	Sept. 15.	Feb. 22, 1899	160				
July 19..	Nov. 9, 1898	113					Sept. 16.	Feb. 21, 1899	158				
July 21..	Nov. 12, 1898	114					Sept. 19.	Feb. 26, 1899	160	May 23, 1899	246	203	86
July 23..	Nov. 26, 1898	116					Sept. 22.	Feb. 23, 1899	154				
July 25..	Nov. 27, 1898	125	Jan. 10, 1899	169	147	44	Sept. 27.	Mar. 3, 1899	157				
July 29..	Nov. 30, 1898	124					Sept. 28.	Apr. 11, 1899	195				
Aug. 3..	Dec. 28, 1898	147					Sept. 30.	Apr. 10, 1899	192				
Aug. 14..	Dec. 27, 1898	135	Jan. 20, 1899	159	147	24	Oct. 4..	May 1, 1899	209				
Aug. 26..	Jan. 6, 1899	133	Apr. 11, 1899	228	182	95	Oct. 7..	May 3, 1899	208				
Aug. 30..	Jan. 6, 1899	129	Apr. 11, 1899	224	177	95	Oct. 10..	May 5, 1899	197				
Sept. 5..	Jan. 15, 1899	132	Apr. 18, 1899	225	179	93	Oct. 13..	May 8, 1899	207				
Sept. 6..	Jan. 30, 1899	146	May 3, 1899	239	193	93	Oct. 20..	May 6, 1899	198				

From this record the following summary has been prepared:

Eggs taken in 1898.	Hatch first (in days).	Hatch last (in days).	Average hatching period.	Average range in hatching.
July	113	151	133	37
August	136	204	169	71
September	161	242	198	88
October	204	(?)	(?)	(?)

In 1899 there were spawned 2,837 red salmon, as follows:

Spring run.		Fall run.	
Date.	No.	Date.	No.
June 27–30	14	Aug. 28–31	23
July 1–31	1,357	Sept. 1–30	1,178
Aug. 1–10	60	Oct. 1–31	195
		Nov. 3	10
Total	1,431	Total	1,406
			1,431
Grand total for season, 1899			2,837

Of the season's take the spring run therefore amounted to 50.4 per cent as against 49.6 per cent for the fall run. Considering the season as a unit, the monthly percentages of fish spawned are as follows: June, 0.5 per cent; July, 47.9 per cent; August, 2.9 per cent; September, 41.5 per cent; October, 6.8 per cent; November, 0.4 per cent.

Taken at the usual hatchery count of 3,000 eggs per average spawn fish, there should have been basketed more than 8,500,000 eggs, but the superintendent has only credited the hatching-house with 6,000,000, "owing to shrinkage in various ways."

The first eggs were taken June 27 from a few fish, but were not basketed; the milt curdled when it came in contact with the eggs, and it was not thought impregnation would take place. Spawning was again carried on June 30, when the milt once more curdled upon contact with the eggs, and none of the latter were basketed. July 3 the first eggs were placed in the troughs, although the same condition of milt was met with. This curdling tendency continued in a diminishing degree for about a week longer, when it ceased; strange to say it did not affect the vitality of the sperm as far as could be judged. Spawning was carried on about every other day in July, the run slacking up toward the latter part of the month; in August eggs were taken three times up to the 10th, from which time until the 28th none were taken. With the beginning of the fall run work went on once more every other day until the end of September; during October spawn was taken on an average of about once a week, and the last stripping of 10 fish was done November 3. On the last-mentioned date about 40 adult salmon, still unripe, were released from the reservoir and turned into the river.

The period of incubation varies with the temperature of the water, of course, but it is also believed to be of less duration with eggs taken from the spring run than is the case with those of the later or fall run. That is, the eggs of the spring run of redfish seem to have a more vigorous vitality, hatching more rapidly under similar thermal conditions; but this is still a matter of opinion and must remain so until the collection of sufficient data from which to draw careful conclusions.

From the meager figures at hand for the 1899–1900 season the following table has been prepared:

Eggs taken in 1899.	Eyed.	Hatching period.			Hatching range.	Premature births.	Remarks.
		First.	Last.	Mean.			
July 3	30	74	109	92	35	23	
July 13	40	.....	125	.....	.....	.....	
July 15	.....	109	132	121	23	.....	
July 31	.....	93	185	139	92	62	Delicate period, Sept. 1–Oct. 15.
Aug. 3	.....	.....	.....	.....	.....	90	
Aug. 10	.....	127	202	165	83	75	
Aug. 28	65	126	199	163	73	74	Delicate period, Oct. 20– ?
Sept. 7	64	161	266	184	45	.....	
Sept. 10	62	158	214	186	56	.....	
Sept. 14	75	154	218	186	64	.....	
Sept. 20	81	162	223	193	61	.....	
Sept. 30	89	207	237	222	30	.....	
Oct. 14	110	199	230	215	31	.....	
Oct. 27	125	186	.....	.....	.....	.....	
Summary.							
July 3–15	35	91	122	107	31	.....	Spring run.
July 31–Aug. 10	.....	110	193	151	83	.....	
Aug. 28–Sept. 20	69	152	212	182	60	.....	Fall run.
Sept. 30–Oct. 27	108	197	233	215	36	.....	

Eggs taken in 1899.	Eyed.	Hatching period.			Hatching range.
		First.	Last.	Mean.	
Spring run	35	100	158	129	58
Fall run	88	174	222	198	48
Season	61	137	190	163	53

NOTE.—In the above table a day of 24 hours is the unit.

It would appear from the above that the eggs eye very much faster with the spring run, and that the hatching range covers a much longer period. It is also apparent that in considering the hatching of redfish at Karluk the two runs must be treated separately—the runs are so marked and the prevailing conditions so radically different. For example, eye-spots have appeared in 30 days in spring-run eggs, and have with fall-run eggs been as long as 138 days before being visible. With the early run eye-spots are looked for between 35 and 40 days, the interval advancing with the season; with fall eggs the eye-spots are not expected until more than two months have passed, the time again increasing with the advancement of the season. The "tender stage" is a variable quantity, difficult to calculate; it is carefully looked for within about three weeks from the stripping, but may not occur for as many months. Its duration is also variable, anywhere from one to five or six weeks, depending upon the temperature, and it is thought, other conditions not yet known. This season, 1900, no tender condition had made its appearance up to August 8.

The period of incubation ranged in 1899 from 74 days to 237 days, and there is a maximum record for some prior season of 244 days. The early run in 1899, under natural conditions of temperature, hatched in an average of 129 days, whereas the fall run required 198 days. Seven months is supposed to be the period of incubation under natural conditions, with the temperature at a mean minimum during the coldest months of between 33° and 35° F., and this seems to be a fairly correct approximation, judging from the record of the October eggs of 1899 and the following temperature record:

Temperatures in hatching troughs, winter 1899–1900.

Month.	Mean maximum.	Mean minimum.	Mean.
	°	°	°
October, 1899	42	40	41
November, 1899	40	38	39
December, 1899	+37	36	−37
January, 1900	−37	+35	36
February, 1900	37	35	36
March, 1900	38	36	37
April, 1900	39	36	+37

In 1900 the seining crew delivered into the river corrals 79,753 adult salmon. Of this number 13,123 escaped from time to time through the water gate when opened to admit live-cars, and through breaks in the corral fences during the time the corrals were in use, 114 days; there were also lost 7,334 stock-fish at a time when the fencing of one of the corrals blew down. The proportion of males to females among these 20,457 fish which escaped alive is, of course, unknown. The remaining 59,296 comprised 33,523 males and 25,773 females, which are accounted for as follows:

	Males.	Females.	Total.
Died on hand	14,324	19,498	33,822
Returned to river alive	19,199	6,275	25,474
Total	33,523	25,773	59,296

Of these fish 7,270 males and 15,579 females, or a total of 22,849, were transferred to the ripening-ponds during the season, as follows:

Month.	Males.	Females.	Total.
June	1,931	3,974	5,905
July	2,296	5,574	7,870
August	2,225	3,658	5,883
September	818	2,373	3,191
Total	7,270	15,579	22,849

No report of the egg-take for the season has been received, but 5,524 females were spawned in all. Applying the usual Karluk hatchery factor of 3,000 per average fish, the take would appear to have been 16,582,000 eggs. Allowing, however, for "other shrinkage in various ways," and judging from the hatchery capacity, 15,000,000 eggs would appear to be a fair estimate.

According to a report from the hatchery, under date of November 3, 1900, all the June eggs and part of the July eggs had hatched out, producing an excellent lot of healthy fry. It was found (1900) that the earlier eggs and the September eggs were the best, while a portion of those taken during the middle of the season were of indifferent quality.

The following temperatures of the water in the hatching-troughs are recorded:

Month.	High.		Low.		Mean.	Remarks.
	Max.	Mean.	Min.	Mean.		
	°	°	°	°	°	
May, 1900	48	43	36	38.7	40.9	
June, 1900	57	49.3	39	41 7	45.5	57° June 28.
July, 1900	57	51	43	45	48	57° July 9.
August, 1900	56	50.2	42	46.3	48.2	
September, 1900	48	46.1	39	43.1	44.6	
October, 1900	46	41	34	40	40.5	
November, 1900	39	36.6	34	36.1	36.3	
December, 1900	38	35.3	33	34.7	35	33° Dec. 22 and 31.
January, 1901	36	34.4	34	34.3	34.3	

The eggs of the redfish readily admit of forcing, but to what extent is not known. Judging from the fact that "freaks" or malformations and prematures occur anywhere from 20 to 80 days, 90 days would seem the limit of safety, but at what temperature the limit is reached is not yet known. At Karluk fall-run eggs have been successfully forced to hatch in 165 days, or say 45 days sooner than would have been the case under natural conditions. To do this the temperature during the last 42 to 45 days—that is, after the one hundred and twentieth day—was artificially raised to 46° and 48°, or 10° to 12° higher than otherwise would have obtained. It has been observed that during warm misty or rainy weather eggs which are nearly ready to hatch will be hastened by several days.

After a basket of eggs has been placed in a trough at the Karluk hatchery it receives the most tender care. For the first two or three days the basket is not touched, but remains "buried" under the canvas tarpaulin; it is then handled once a day for the next four or five days by the superintendent himself, who merely floats the eggs once, very gently, and picks off the dead eggs and "empties" showing on top; after

this, and until the "unctuous" stage has passed, an expert egg-picker removes the bad eggs, the superintendent having previously floated them on top. When the unctuous stage, lasting from eight to twenty days, during which the eggs are very delicate and have a certain indescribable oily appearance, has passed, the basket is henceforth in the hands of one of the hatching-house force, who is responsible for it until the end.

Ordinary tin forceps are employed in picking, but they are critically examined by the superintendent before they are used, to see that there are no sharp edges or corners to cut the tender skin of an egg. Frequent inspection of the forceps continues throughout the season. The eggs are picked very thoroughly until the second tender period begins, usually a short time before eyeing takes place; after this stage has passed the eggs may be handled with greater freedom, but vigilance and tender care are observed throughout the season. Jars, sudden knocks, rapid changes in temperature, or other shocks are particularly guarded against, and a basket of eggs is never lifted from a trough when it can be avoided. In affixing to the trough the small pasteboard tag describing the basket, no hammer is used, but the broad-headed and short, sharp-pointed tack is forced home with the thumb. Great care is taken to keep the troughs and baskets clean, and to have the feed water well filtered. As yet there has not been the least trouble from fungus. There is a slimy vegetable growth which forms on the sides of the troughs under certain conditions, which must be removed, but which does not spread to the eggs like fungus; it is probably some species of fresh-water algæ.

After the fry are hatched out they escape to the bottom of the trough, there being one-half inch clear space on either side of the basket, somewhat more than that under it, and in addition there is the large area at the end of each trough created by the removal of the fifth basket; this gives the fry plenty of room, and they do very well in the troughs. As they age they require more space, but they are usually held in the parent trough until the egg—or umbilical—sac is absorbed, a period of about ten weeks, depending upon the temperature of the water.

The fry must then be fed, which is sometimes done in the trough and sometimes in the reservoir pond. The only food ever used at Karluk has been tinned salmon flesh, "do-overs," furnished from the canneries at Karluk Spit. This is removed from the can, thoroughly desiccated, and then ground up in a fine-cutting sausage mill. For some reason the fry do not seem to thrive on this diet, refusing to take it after ten days or two weeks, and it is therefore the endeavor to plant them as soon after becoming free feeders as is possible; it makes a wonderful difference in the quick growth and development of the fry if they can obtain natural food. The fry appear to be of a generally dormant temperament during the time the sac is being absorbed, and there has been very little loss at Karluk during this period; the greatest losses to fry occur at the time of first feeding.

As they become free feeders they are allowed to escape from the troughs via the wasteway into the reservoir pond, and thence through the ditch into the rearing or nursery pond—a large, irregular-shaped excavation, with an area of about three-fourths of an acre. Owing to the cannibalistic tendencies of the larger fry, the young with the egg sac still attached are kept by themselves. The tiny free feeders, however, seem pretty well able to take care of themselves. As opportunity offers, the fry are taken

from the large nursery pond and planted; or, if the nursery be frozen over, they are taken from the reservoir and parent troughs, where they have been held on this account. After the fry are three or four months old it has been observed that they seem to deteriorate in the nursery ponds, and they are never held beyond this time.

When the ponds and upper part of the lagoon are frozen over, the fry are placed in tanks prepared for them, transported on sleds to the open water, and planted. These tanks are made of clean, strong, salt-salmon barrels thickly coated with asphaltum varnish and rigged with handles, or beckets, of rope. Three of these are a sled load, and comprise a "plant," which usually numbers about 100,000 by this method. When the ponds and lagoon are open and free from ice, the fry are driven out of the rearing-pond at high water, through a short flume, into a live-car made of an old skiff. This skiff, which has a number of square ports cut in its sides, covered with fine mesh wire netting, is brought directly under the short flume, which leads from one corner of the pond to the lagoon beach. It has a capacity of over 200,000 fry. When the live-car is loaded the wire-screen gates are let down across the inner end of the flume and the further exit of fry stopped.

Planting is done at high water along the shores of the lagoon between the mouth of the river and the upper end of the village at Karluk. The location selected depends upon the existing conditions, ice, waves, and the movements of predatory species being considered. As far as possible a rocky shore whose crevices afford safe retreats, away from the entrance of fresh water where trout are attracted, is chosen, and the fry released without further preliminaries. It is claimed that no salmon fry has ever been planted at Karluk with the egg sac not entirely absorbed.

The superintendent firmly believes that the strong free-feeding fry early crave salt water, and he usually has a barrel containing a small quantity of salt submerged in the large nursery pond. It has been observed that the fry collect about this like flies after sweets, and the salt appears to act upon them like a tonic, making them more sprightly and vigorous in their movements.

After being set free the fry have been observed to work downstream alongshore toward the salter portions of the lagoon, which is fairly brackish except at the higher tides, when it is quite salt, or at the lowest tides when the river is full, when the lagoon is practically fresh. Later the fry are seen along the outside beaches in the vicinity of the shaded rocky points, but return to the lagoon at frequent intervals, working in and out with the tides for a long time, or until late in the fall following their birth. Some fry are much stronger and larger than others and grow very rapidly. Two or three were seen in the nursery pond August 8, 1900, which were from 2 to 3 inches in length and very timid. In April, 1897, fry from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long were seen in small schools passing seaward from Karluk River, and the fry hatched in the spring of 1898 were from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches, some 2 inches, in length in the nursery pond in August.

Trout are believed to be the most destructive natural enemies the fry have to contend with. An individual (*Salvelinus malma*) only $2\frac{1}{2}$ inches in length which once found its way into the nursery pond had 12 tiny fry in its maw when captured. The trout are not such active feeders in the winter, and are more sluggish in movement, and it is therefore deemed advisable at Karluk to plant fry at this season. Other natural dangers are also believed to be lessened at this time.

After the trout the greatest enemies to fry are perhaps the sea birds. Flounders and sculpins are too sluggish in their movements, besides being bottom fish, to be very destructive. Sudden storms, raising a heavy sea on the shore along which the fry are schooling, are also dangerous.

The loss of the hatchery in the ratio of fry planted to the number of healthy eggs basketed it is believed at present will not amount to 25 per cent from all causes, although during the first season it was figured at not far from 40 per cent. The greatest present loss is from dead eggs and "empties," or unfecundated eggs. This is not now as much as 15 per cent, and gradually diminishing as experience is gained. The loss from freaks and abortions and premature births, all combined, is nominal, but is greatest in the eggs of the spring run. It is not of itself considered a factor, but is lumped with the losses from other causes. Deaths due to smothering of the tiny fry during the period of absorption of egg sac, through injuries received in various ways while in the troughs and reservoir, with the other losses just mentioned, will make up a conservative total loss of 25 per cent. The superintendent believes his 1900 loss should not be much in excess of 20 per cent unless from some unlooked-for calamity.

The superintendent believes in the *parent region* theory, and thinks that the Karluk fishery has already this year (1900) felt the value and effects of artificial propagation. He thinks that the largest and strongest of the fry planted in the winter of 1896–97 and spring of 1897 have become matured, that this year they returned as breeders, and that their numbers were sufficient to make an appreciable increase in the runs of salmon schooling off Karluk Head, and possibly Ayakulik River. He believes they first put in an appearance as grilse, invariably males, which are thoroughly matured, and that these grilse are 2 years old, that is, from birth. Part of the breeders, he thinks, return in three years, while others of slower development return in four or five years, and it is not beyond the bounds of reason to presume that some may be delayed for an even longer period before reaching full maturity.

In 1897 the adipose fin was cut from 513 fry, part of which were liberated in Karluk River and part in the lagoon.

The approximate output of the Alaska Packers Association's redfish hatchery at Karluk is estimated as follows:

	Fry liberated.
Season 1896–97	2,000,000
1897–98	5,000,000
1898–99	5,000,000
1899–1900	6,000,000
1900–1901	12,000,000
Total output	30,000,000

Sketch-Plan of Red-Salmon
operated by Alaska Packers As
Shasta Creek, Karluk Lagoon. Kad

Scale 1/15" = 1'; dimensions arbit

Reservoir Pond.

A. Discharge escape.
B. Receiving basin.
C. Compartment for spawned fish.
D. Pipes from heating system.

Divisions are of slats

Outlet to Rearing Pond.

Reservoir (Housed-in.)

Rubble and Cement Wall.

Hot-Water Drum

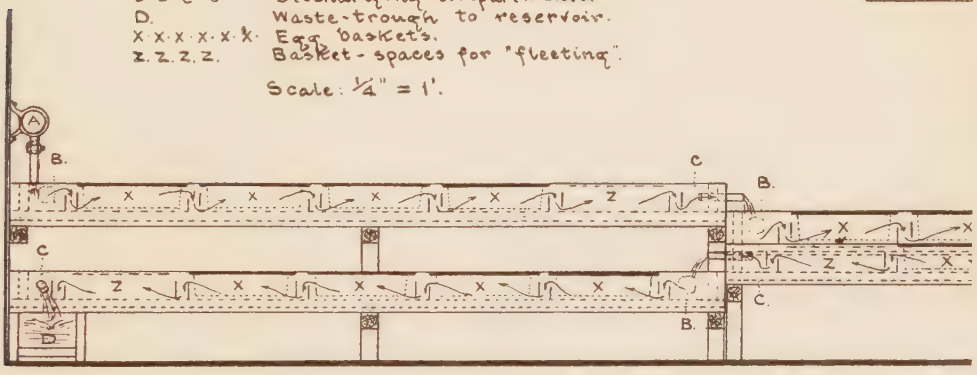
Hatchery.

Stairs (Down)

Section of Set of 4 Hatching-Troughs.

A. 6" Supply-pipe from filter-tank.
B·B·B·B· Receiving and aerating compartments.
C·C·C·C· Discharging compartments.
D. Waste-trough to reservoir.
X·X·X·X·X·X· Egg baskets.
Z.Z.Z.Z. Basket-spaces for "fleeting".

Scale: 1/4" = 1'.



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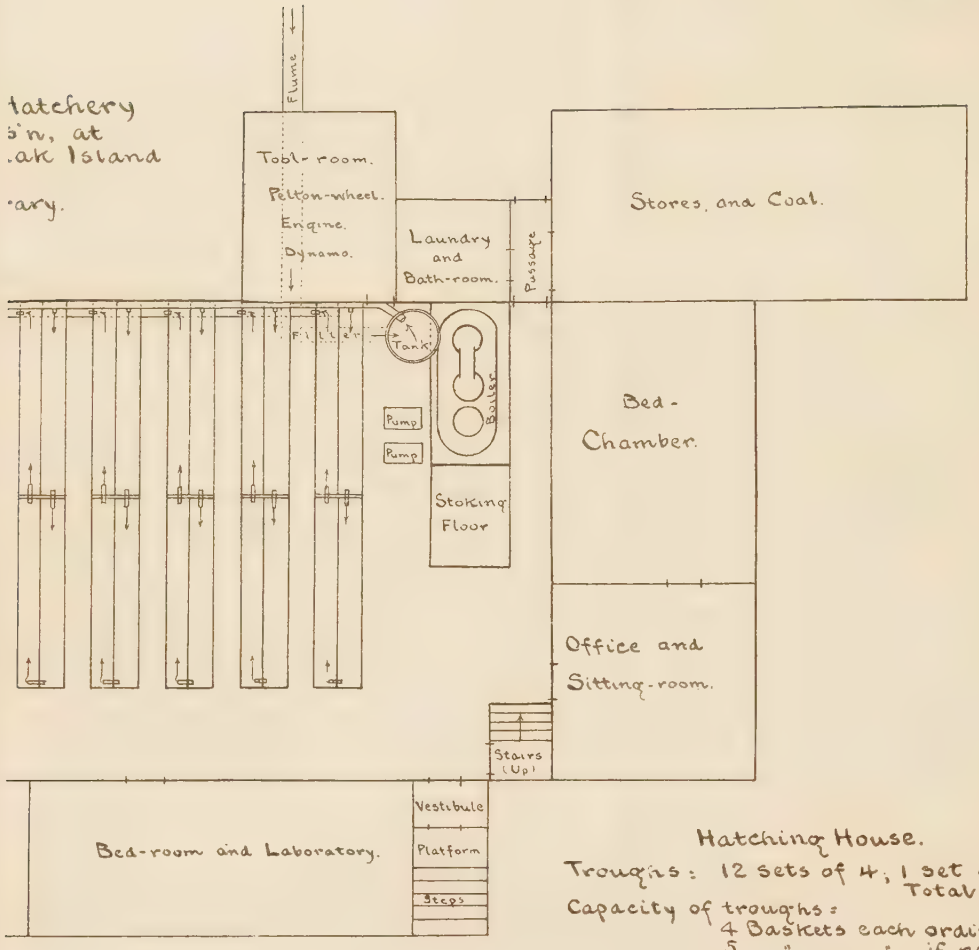


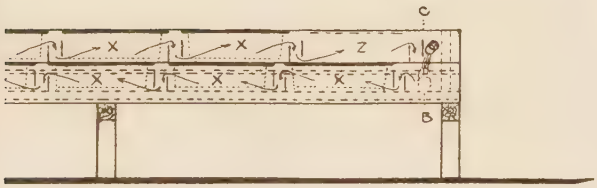
Hatching House.

Troughs: 12 sets of 4, 1 set of 3.
Total 51.

Capacity of troughs:
4 Baskets each ordinarily.
5 " " if necessary.
204 to 255 Baskets.

Capacity of baskets:
25 females at average of
3,000 eggs, or 75,000 Eggs.

Capacity of hatchery:
Under ordinary cond^ns, 15,300,000.
If necessary, 19,125,000.



SALMON INVESTIGATIONS OF THE STEAMER ALBATROSS IN THE SUMMER OF 1901.

By JEFFERSON F. MOSER,
Commander, United States Navy, Commanding.

After refitting during the winter of 1900–01, at Sausalito, Cal., the *Albatross* left that point, April 23, for Puget Sound, under instructions to dredge along the coast in depths greater than 1,000 fathoms. Upon the completion of this work a special report relating to it was made, and the records are printed in the report of the United States Commissioner of Fish and Fisheries for 1901.

Owing to the strikes and the disturbed condition of labor on the coast at this time, the vessel was detained for docking and painting until May 22, when departure was taken from Seattle. After coaling at Union Bay, British Columbia, the vessel arrived, May 29, at Hunter Bay, Prince of Wales Island, Southeast Alaska, and the same day field operations were commenced. The work for the season, under the Commissioner's instructions, consisted in a continuation of the explorations of the salmon streams and lake systems of Alaska on the lines carried out during previous years, and an examination of the canneries and hatcheries along the route.

During the progress of the work in Prince William Sound a case of small-pox appeared among the crew, causing an earlier return to Puget Sound, for quarantine and fumigation, than was contemplated. The stream and lake work had been practically completed, but the early return did not permit an examination of all the new canneries. After obtaining pratique at the quarantine station at Port Discovery the season was too far advanced to return to Alaska, and the vessel was accordingly detailed for special work extending from Puget Sound to Monterey.

Owing to my early detachment from the command of the *Albatross* and the lack of facilities for making a complete report consequent thereto, many of the details previously referred to have been omitted, and this paper will be largely confined to descriptions of the streams and lake systems explored by the party during the season.

It is desired in this connection to express my appreciation of the work performed by the officers of the *Albatross*, and of the courtesies extended by those interested in the canneries. Lieut. Hugh Rodman, U. S. N., Ensign A. J. Hepburn, U. S. N., Ensign C. R. Miller, U. S. N., and Ensign C. S. Kempff, U. S. N., in addition to their duties on board the vessel, conducted the stream and lake examinations. Mr. A. B. Alexander collected statistics, Mr. F. M. Chamberlain made the photographic plates, and Mr. H. C. Fassett assisted me and, under my direction, made special investigations. My thanks are due to the different companies operating canneries in Alaska for courtesies extended during our investigations, particularly to the Alaska Packers' Association, which has, through the president, Mr. Henry F. Fortmann,

placed at our disposition the facilities of its various plants and rendered most efficient assistance.

The following is the itinerary of the Alaska cruise:

Southeast Alaska:
- Hunter Bay, Prince of Wales Island.....May 29–31.
- Niblack Anchorage, Prince of Wales Island .....May 31–June 1.
- Moira Sound, Prince of Wales Island....June 1.
- Tamgas Harbor, Annette Island.....June 1–3.
- Metlakahtla, Annette Island .....June 3.
- Ketchikan, Tongass Narrows, Revillagigedo Island.....June 3–5.
- George Inlet, Revillagigedo Island.....June 5.
- Mary Island Anchorage .....June 5–6.
- Kah-Shakes Cove, entrance to Boca de Quadra .....June 6.
- Smeaton Bay, Behm Canal .....June 6–7.
- Checats Cove, Behm Canal .....June 7.
- Yes Bay, Cleveland Peninsula.....June 7–8.
- Loring, Naha Bay.....June 8–10.
- Ketchikan, Tongass Narrows, Revillagigedo Island .....June 10.
- Steamer Bay, Etolin Island.....June 10–11.
- Kunk Creek, Etolin Island .....June 11.
- Wrangell, Wrangell Island.....June 11–13.
- Salmon Bay, Prince of Wales Island.....June 13.
- Conclusion Island (off Kuiu Island) ....June 13–14.
- Point Barrie, Kupreanof Island.....June 14.
- Port Protection, Prince of Wales Island..June 14–15.
- Shakan Bay, Kosciusko Island .....June 15–17.
- Kell Bay, Kuiu Island.....June 17–18.
- Killisnoo Harbor, Kenasnow Island.....June 18–19.

Southeast Alaska—Continued.
- Kook (Basket) Bay, Chichagof Island...June 19.
- Pablof Harbor, Freshwater Bay.....June 19–21.
- Juneau.....June 21–24.
- Hunter Bay, Admiralty Island .....June 24–25.
- Bartlett Bay, Icy Strait.....June 25–27.
- Dundas Bay, Icy Strait .....June 27–29.
- Yakutat.....June 30–July 7.

Prince William Sound:
- Orca .....July 8–10.
- Port Gravina.....July 10–11.
- Naked Island Anchorage.....July 11.
- Herring Bay, Knight Island.....July 11–15.
- Naked Island Anchorage.....July 15–18.
- Port Valdez.....July 18–21.

Southeast Alaska:
- Sitka.....July 23–25.
- Nakwashina Bay, Baranof Island.....July 25–Aug. 3.
- Schultze Cove, Baranof Island .....Aug. 3–4.
- Hanus Bay, Baranof Island .....Aug. 4–5.
- Sitkoh Bay, Chichagof Island .....Aug. 5–6.
- Hoggatt Bay, Baranof Island.....Aug. 6–7.
- Baht Harbor, Zarembo Island .....Aug. 7–8.
- Steamer Bay, Etolin Island.....Aug. 8–11.
- Ward Cove, Tongass Narrows, Revillagigedo Island .....Aug. 11–12.

Washington:
- Port Discovery, Quarantine Station.....Aug. 17.

Before the opening of the season it was believed that there would be a very large number of new canneries operating during the summer, but the drop in the price of salmon made it difficult for some prospective canners to raise sufficient funds on futures to place them on a working basis, while others feared that overproduction beyond the world's demand would bear market prices below cost; nevertheless, there was a large addition, which will be referred to later. It had been the intention early this year to form a trust of the Pacific salmon canneries, but failing to make terms with the largest operating company, the scheme resulted simply in a consolidation of a portion of the canneries.

An organization under the title of the Pacific Packing and Navigation Company, incorporated under the laws of New Jersey and backed by eastern capitalists, was formed during the spring of 1901. Its object is given in a "statement," under date of March 12, 1901, in which it is said:

> It is proposed to consolidate into one corporation the properties and privileges of these companies and firms, thereby controlling about four-fifths of the canned-salmon product of the world. * * * It is proposed to capitalize the new corporation as follows: 6 per cent debentures, $7,000,000; 7 per cent cumulative preferred stock, $12,500,000; common stock, $12,500,000.

The Alaska Packers Association, whose output in past years has been about 70 per cent of the Alaska salmon pack, demanded of the trust a cash payment for their business at their own valuation. The trust offered the amount, but payment to be made partly from the sale of this season's product and the remainder in mortgages on their own property and stock in the new company, which offer was declined.

The Pacific Packing and Navigation Company acquired the following properties, and they are now operated by that organization:

ALASKA.

Canneries of Pacific Steam Whaling Company at Nushagak, Bristol Bay; Chignik, Alaska Peninsula; Uyak, Kadiak Island; Kenai, Cook Inlet; Orca, Prince William Sound; Hunter Bay, Southeast Alaska.
Hume Bros. & Hume, with canneries at Chignik, Alaska Peninsula, and Uyak, Kadiak Island.
Thlinket Packing Company, canneries at Gerard Point and Santa Anna Bay, Southeast Alaska.
Western Fisheries Company, with a cannery at Dundas Bay, Icy Strait.
Chilkoot Packing Company, with a cannery at Chilkoot Inlet.
Taku Packing Company, with a cannery at Taku Inlet.
Taku Fishing Company, with a cannery at the entrance to Port Snettisham.
Boston Fishing & Trading Company, with a cannery at Yes Bay.
Chatham Straits Packing Company, with a cannery at Sitkoh Bay.
Icy Strait Packing Company, with a cannery at Petersburg, Wrangell Narrows.
Quadra Packing Company, with a cannery at Mink Bay, Boca de Quadra.

PUGET SOUND REGION, WASHINGTON.

Pacific-American Fisheries Company, with canneries at Fairhaven and one at Friday Harbor.
Ainsworth & Dunn, with canneries at Seattle and Friday Harbor.
Fairhaven Canning Company, with a cannery at Fairhaven.

The new concern also acquired a hatchery near the entrance to Freshwater Bay and one in the Boca de Quadra, Alaska.

As the histories of the Alaska canneries have been given in my former reports, reference will be made here to the canneries located in Washington and absorbed by the new company.

The Pacific American Fisheries Company was incorporated in 1899 under the laws of New Jersey. This company purchased at the time of its organization the cannery and trap properties of the Island Packing Company, San Juan Island, and the cannery of the Franco-American North Pacific Packing Company at Fairhaven, the latter concern having been promoted the year previous. The "P. A. F.," as it was locally known, also acquired about thirty independent trap locations in the adjacent waters of Washington.

Ainsworth & Dunn had one cannery at Blaine and one at Seattle, and a number of trap locations. This business had grown up gradually, during a period of seven or eight years, from a small beginning in the fresh-fish trade to a prominent position in the Puget Sound salmon industry.

The Fairhaven Canning Company was a Washington State corporation, owning one cannery at Fairhaven and several trap locations.

The Pacific Packing and Navigation Company therefore represents a combine of twenty-three canneries with their equipage. The company claims an Alaska pack for 1901 of about 700,000 cases, and expects to increase its output so as to have a total capacity of 1,000,000 per season.

Returning to the cannery conditions in Alaska, there are now two large corporations and sixteen independent canneries. The Alaska Packers' Association easily leads in this enterprise, with a pack this year of 50 per cent of the total. The Pacific Packing and Navigation Company follows with about 30 per cent. The remaining 20 per cent are distributed among the following independent concerns: Alaska Salmon Company, Columbia River Packers' Association, Portland-Alaska Packers' Association,

and Alaska Fishermen's Packing Company, all on the Nushagak; North Alaska Salmon Company, on the Kvichak; Naknek Packing Company, on the Naknek; Bristol Packing Company and Red Salmon Packing Company, on the Ugashik; Alaska Salmon Association, on Cook Inlet; Fidalgo Island Canning Company, Ketchikan; Metlakahtla Industrial Company, Metlakahtla; North Pacific Trading and Packing Company, Klawak; Pacific Coast and Norway Packing Company, Blunt Point, Wrangell Narrows; Union Packing Company, Kell Bay; San Juan Fish and Packing Company, Taku Harbor; and F. C. Barnes & Co., Lake Bay, Prince of Wales Island.

NEW CANNERIES IN SOUTHEASTERN ALASKA IN 1901.

In southeastern Alaska six new canneries were built and operated and two were rebuilt during the season, as follows: Thlinket Packing Company, in addition to their cannery at Gerard Point, at the mouth of the Stikine River, erected and operated a plant called No. 2 in Santa Ana Bay, Seward Passage. The Pacific Coast and Norway Packing Company, which during 1900 operated a salting plant in Wrangell Narrows, erected and operated a cannery in the Narrows at Blunt Point. The Chatham Straits Packing Company, a branch of, or promoted by, the Icy Strait Packing Company, operated a cannery on the southern shore of Sitkoh Bay, about 4 miles from Point Craven. The Union Packing Company built and operated a cannery in Kell Bay, Kuiu Island. Canneries were also built and operated at Lake Bay, Prince of Wales Island, by F. C. Barnes & Co., and in Taku Harbor, by the San Juan Fish and Packing Company. The Alaska Packers Association rebuilt their canneries at Loring and Wrangell and installed modern plants at both places. Three new canneries only were visited in southeastern Alaska, as time did not permit our calling at all the points.

Union Packing Company.—This company, with home address at Tacoma, was organized under the laws of the State of Washington, and built a cannery during the spring of the year on Kell Bay, an arm of Affleck Canal, on the southern end of Kuiu Island. The buildings are located on the southern arm of the bay inside a cluster of islands. The capacity of the cannery is placed at 600 cases per day. The outfit was for 25,000 cases, with a Chinese guaranty of 20,000 cases. The Chinese contract was 44 cents per case, with the usual conditions. The fishermen contracted for their transportation and board, $35 per month, and for each crew of 7 men, collectively, a bonus of 1 cent for each redfish and coho, $4 per thousand for dog salmon, and $2 per thousand for humpbacks. Transportation by calling freight steamers of a regular line. If the conditions should hold good, it was the intention to fish for halibut after the close of the salmon-packing season.

Alaska Salmon Packing and Fur Company (*A. P. A.*), *Loring.*—During the spring of 1901 the old cannery buildings were pulled down, new buildings were erected, and new machinery installed on the old site for a first-class three-filler plant. The main cannery building is 240 feet by 50 feet, of which 70 feet is two-story; parallel to it and connected by a broad platform is a two-story warehouse, 170 feet by 60 feet, with an ell 120 feet by 40 feet. Part of the old building, 60 feet by 35 feet, has been retained for a box-house. There are two wharves—the upper one having sufficient depth alongside for vessels to lie while loading, the lower one is used for berths for the cannery tenders. The Y slip for discharging fish from the tenders, referred to in my 1900 report has been extended.

CHENIGA STREAM, PRINCE WILLIAM SOUND, ALASKA

The following canning machinery is installed: 2 cutters, 3 fillers, 3 toppers, 3 solderers, 10 retorts, 2 sets of cannmakers (complete with 2 toppers and 2 solderers), and 2 fish-cleaning machines. The cannery has a capacity of 2,400 cases a day, and was ready for operation for the first run of fish this season. All the tins were made at the cannery, of 100-pound domestic plate. The canning machines were run at the rate of 55 per minute for each set.

Glacier Packing Company (*A. P. A.*), *Point Highfield, Wrangell.*—As the old cannery was no longer suitable for the purpose, it was pulled down during the season and a new enlarged cannery with the latest machinery was constructed on the site of the old plant. The cannery building proper, a structure 238 feet by 50 feet, of which 138 feet is two-story, was ready for the season's pack, and the warehouses and other buildings were erected during the season and after the runs were over. All cans were made by hand at the cannery, except 1,200 cases of flats which were carried from San Francisco. The tin plate was of domestic manufacture, 100-pound weight.

Several of the older canneries were visited in southeastern Alaska, but no marked changes were noted from conditions existing in 1900, except a general tendency to improve methods, better machinery, and increased facilities for making a larger pack.

It may be of interest here to note that during our visit in the vicinity of Burroughs Bay it was learned that the Indians during the past two years have taken quite a number of shad.

NEW CANNERIES, WESTERN ALASKA, 1901.

From Cross Sound to Bering Sea there were no additions to the canneries, but the latter district received six new ones and enlargements to several old plants.

The Portland-Alaska Packers' Association built a cannery at Snag Point, on the Upper Nushagak Bay. The location is in front of the village, a short distance above the A. P. A. cannery known as the Alaska Packing Company, or the Johnson plant.

The Columbia River Packers' Association constructed a cannery at the mouth of Clark Creek, above the Nushagak Canning Company's reserve plant (A. P. A.).

The Alaska Salmon Company erected a canning plant on the right bank of Wood River, about 2 miles from the mouth, and abreast of the lower point of the first island in the river.

The Red Salmon Packing Company built and operated a cannery on the Ugashik River, about half a mile above the site of the old Bering Sea Packing Company.

The Alaska Packers' Association built an additional three-filler cannery on the Ugashik, on the site of the old Bering Sea Packing Company, and have retained the latter name for the new cannery.

Under the name of the Guardian Packing Company the A. P. A. built a four-filler cannery on the Naknek, about 2 miles below their old cannery, which is operated under the name of the Arctic Packing Company.

The Alaska Packers' Association has also laid the foundation for a large addition to their plant below Koggiung, which was constructed and operated in 1900. In my last report this was called the Kvichak Packing Company, but since then the name has been changed to the Horsehoe Fishing and Mining Company. This addition is to have four fillers and to be ready for operation during the season of 1902.

The Alaska Packers Association have erected a large salmon hatchery on the Naha Lake System, at the head of the Third Lake, within the mouth of the stream

which forms the outlet to the Fourth Lake. This hatchery was located during the season and obtained 12,000,000 redfish eggs.

The association also operated the Callbreath hatchery, on Etolin Island, obtaining about 6,000,000 redfish eggs. At Karluk hatchery, where the run of redfish this season was very large, 32,800,000 eggs were obtained, making the total number of redfish eggs placed in the hatcheries of the Alaska Packers' Association 50,800,000. Counting upon a loss of 20 per cent, this corporation expects to liberate over 40,000,000 fry in the waters of Alaska.

The following is an account of the streams and lakes examined during the season, together with a few remarks on special features of the salmon fisheries.

Pacific Steam Whaling Company's hatchery Hetta Lake.

SOUTHEAST ALASKA.

PACIFIC STEAM WHALING COMPANY'S HATCHERY, HETTA LAKE.

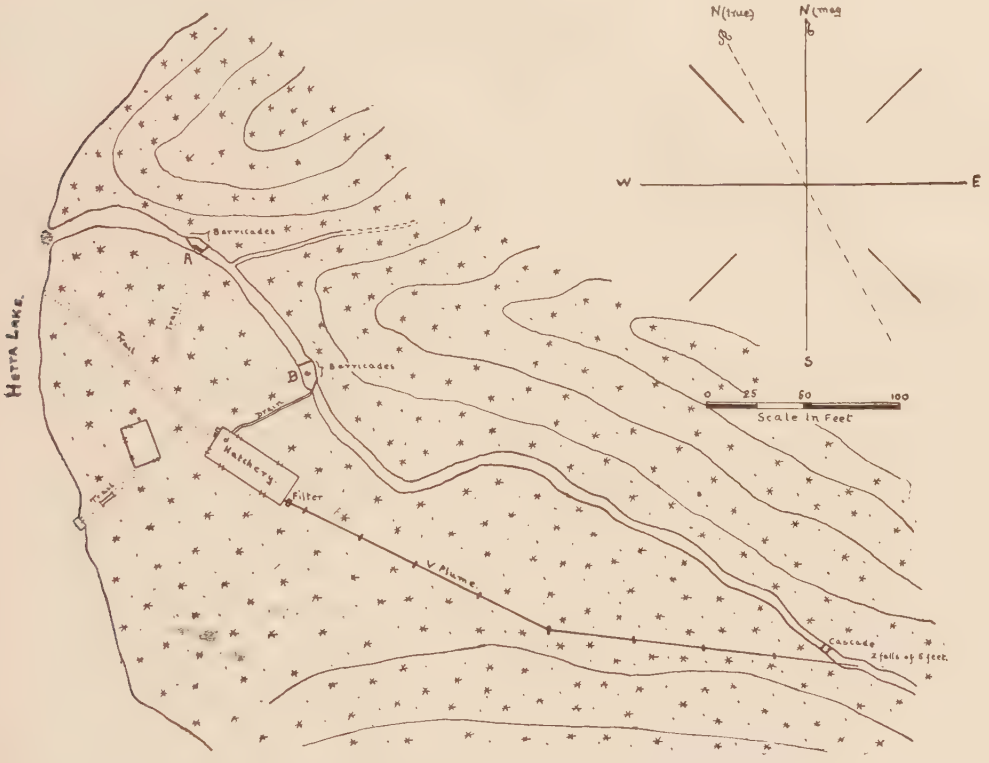
Hetta Stream and Lake were described in my report for 1897 (p. 73–75), and the hatchery was referred to in my report for 1900, but not visited until June 5, 1901, when it was examined by Ensign Kempff and Mr. Chamberlain. For a description of the locality reference is made to former reports.

The hatchery, consisting of hatchery house, dwelling, and boathouse, is located on low, rolling, and heavily wooded land on the southeast shore of the lake, on the left bank of a feeder, from which the hatchery receives its supply of water. The hatchery site is reached from the mouth of Hetta Stream by trail to the lake and by boat across the latter. This feeder is about 10 feet wide, 6 inches deep, and flows with a strong current in a general west-northwest direction, emptying into the lake

about 100 feet to the northward of the main building. The bottom is gravelly, with rocky outcrops in places. There is a cascade of two falls of 5 feet each about 200 yards from the mouth, and about 100 feet beyond this point the stream receives a small tributary from the eastward, the bottom of which is gravelly. Temperature of feeder 43° F.; temperature of lake water 43° F., of lake outlet 50° F.

The hatchery supply is carried from a point just above the cascade for a distance of 325 feet in a flume, the drop of the flume being 12 feet in its length. Outside the hatchery the water is received in a settling tank, 2 feet by 4 feet by 1 foot, partially filled with gravel. A spout 2½ inches by 3 inches leads from the tank into the building, dropping 2½ feet to the head trough.

In the feeder near the hatchery are two nursery pools (A and B), formed by



Sketch of Hetta Hatchery, Prince of Wales Island, Alaska.

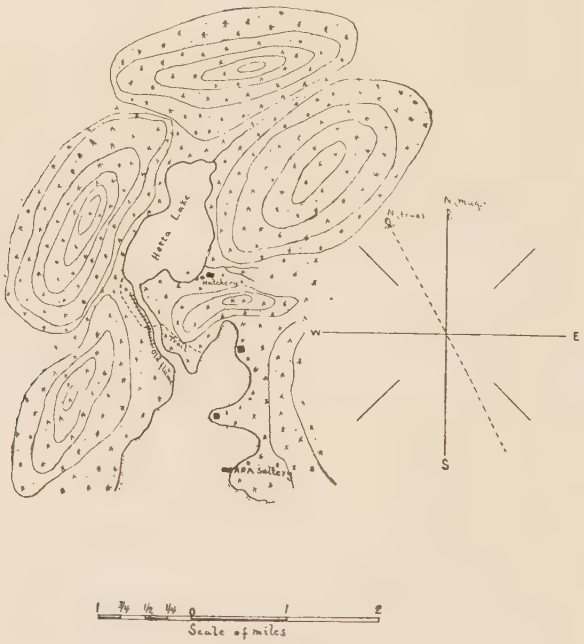
double barricades, and covered with boughs to shade the fry and protect them from birds.

The hatchery building is 50 feet by 26 feet, with side walls 10 feet high, of plank. There are 10 troughs, each 20 feet long, the bottom 12 inches wide, being set in the sides, which are 8 inches deep. They are arranged in 4 batteries, 3 of two troughs each and 1 of four troughs, that is, a double run. They extend lengthwise of the building and are equally distant from each other and from the sides of the building.

The basket divisions are 2½ feet in length, and the division plates, 4 inches apart, are made of light-weight iron, asphalted. The head trough is of the same material

as the hatching-troughs. It is of 12-inch stuff and the sides and bottoms are of the same dimensions. The gates are made by cutting out and resetting the block, leaving a space at the bottom of three-fourths inch by 4 inches. The outflow is controlled by a sheet-iron drop gate. A short tin spout carries water into the troughs, falling about 4 inches. In the double-run battery a similar spout carries the water into the second section with a fall of 2 inches. The troughs drop about 6 inches in their length. The baskets are 24 inches by 11 inches by 5 inches, of the usual material, two-tenths-inch by three-fourths-inch mesh. Wooden battens are secured to the two long sides and the ends protected by a fold of tin nailed to the battens. The corners are interlaced. The baskets are supported in the troughs either by the wooden battens or upon four small blocks one-half inch high, nailed to the bottom of the trough. There were 70 baskets in the house, each having a capacity of 50,000 eggs.

The stock fish are seined in the lake and kept in a retaining pond until fully ripe. The seine used is 30 fathoms by 2 fathoms by 2½-inch mesh. The fish are spawned by the wet process. The spawning pans are tin saucepans, 8 inches in diameter, asphalted. The period of incubation is 90 to 120 days.



Sketch of Hetta Lake and Stream, Prince of Wales Island, Alaska.

The data from this hatchery is exceedingly meager, and not reliable enough for record. It is said that in 1899, 2,800,000 eggs gave 2,600,000 fry (a loss of 7.14 per cent), but this can hardly be correct; in 1900, 1,800,000 eggs were placed in baskets. Very cold weather during the winter of 1900–1901 froze many of the eggs. The output is not definitely known.

PETER JOHNSON STREAM AND LAKE.

This stream is known to cannery people as one of the Moira Sound streams. In conducting the examination of that locality in 1897 it was missed, but it was visited

this season by a party from the *Albatross*, under Lieutenant Rodman, on June 1. It is referred to on page 83 of the 1897 report.

On the eastern side of Prince of Wales Island, between the Wedge Islands and Adams Point, is the approach to a narrow arm, about 2 miles in length, running east and west (true), and now known as Johnson Arm or Inlet. On the northern shore, midway of its length, is a narrow inlet, making to the northward for a distance of about three-eighths of a mile, around which is the new mining camp and post-office called Dolomi, with weekly mail from Ketchikan. The head of this small inlet receives the waters of Peter Johnson Stream, which is the outlet for several small lakes.

Sketch of Peter Johnson Stream and Lake, Johnson Arm, Prince of Wales Island.

The main stream flows in a general southeasterly direction from the main lake for a distance of rather less than a mile, over a bottom which is generally rocky. About one-third mile from the mouth, at a point called The Forks, it receives a small tributary from the northward which itself is the outlet to three small lakes. At the forks a small basin is formed about 75 feet wide and 14 inches deep, the lower end of which is reached by high-water spring tides. The main stream is from 10 to 12 feet wide, and 15 to 20 inches deep; from its source to near the forks it is full of ripples, flowing with a strong current to a broken fall of 4 feet drop about 50 yards above

the forks; thence to the mouth it flows over a series of small rapids. At no point, however, are there any natural obstructions to the ascent of salmon. Near the lake a dam has been constructed across the stream to raise the lake level. It has a board face, sloping at an angle of about 45°, and is arranged to contract the usual flow of water to a width of about 6 feet, which forms a runway. With a full stream it probably is not an obstruction to the ascent of salmon.

About 30 yards above the forks are the remains of an old barricade and a runway formerly used in connection with the funnel-shaped baskets or traps employed by the natives of this vicinity. At the forks are the remains of an abutment probably used formerly in some sort of barricade.

The larger lake, from which the main stream has its source, is known as Paul Lake; it is about 2 miles long and one-fourth mile wide, with the major axis in a WSW. and ENE. direction. It is quite deep, one point, it is said, reaching a depth of 120 fathoms. It is 75 feet above sea level and on June 1 the water, which appeared clear and pure, had a surface temperature of 52° F. Its range in water level is about 4 feet. High hills and mountains border the northern and southern sides. Along the shore the bottom is of gravel with occasional sections of rock and some mud. At the western end the lake receives a feeder in which are spawning-beds for a distance of about one-fourth of a mile. A number of salmon fry were seen in the lake and there were a few small trout above the dam.

The small tributary, previously referred to as joining the main stream at the forks, is about half a mile long, 6 to 25 feet in width and 2 to 10 inches in depth, and flows but a small amount of water. It drains three shallow ponds known as John, William, and James lakes, surrounded by low banks, and full of pond lilies which grow from a muddy bottom.

Lake John is one-half mile from the forks and is 300 yards long and 100 yards wide, with its major axis in a NNW. and SSE. direction; it is reported to have a depth of about 12 feet. The elevation is 25 feet above high-water mark and the temperature of the surface water, June 1, was 53° F.

A shallow streamlet one-half mile in length and with a few unimportant rapids, connects Lake John with Lake James. The latter is about four-tenths mile long, by 175 yards wide, and lies in a general W. by N. and E. by S. direction. It is shallow, and has an elevation of 55 feet. Temperature of surface water, June 1, 52° F.

Lake William is a shallow pond, 250 yards long by 90 yards wide; it has a short outlet, 2½ feet wide by 8 inches deep, flowing through the left bank of the streamlet connecting Lake John with Lake James and very near the former. It has an elevation of 28 feet, and the temperature of the surface water on June 1 was 52° F.

The country surrounding the Peter Johnson stream and lake system is well wooded and covered with the usual growth of the region. This stream is claimed by a native, from whom it derives its name, and furnishes fish to the canneries at Metlakahtla and Loring, although prior to 1896 all of these fish were purchased at Metlakahtla. It is remarkable for the small redfish which it carries, and it is said there is no deviation, from one year to another, in their average weight, which is from 3½ to 4 pounds each. The redfish from this stream are frequently quoted by those who propound the parent-stream theory in support of the argument.

PLATE XXXVI.

SKETCH OF TAMGAS LAKE AND STREAM SYSTEM, EAST SIDE OF TAMGAS HARBOR, ANNETTE ISLAND, ALASKA.

Bull. U. S. F. C. 1901. (To face page 358.)

The following is the record of the fish taken from this stream so far as any data are available:

Year.	Redfish.		Cohoes.		Humpbacks.	
	Dates.	No.	Dates.	No.	Dates.	No.
1892....	July 8–Aug. 18	8,434	Aug. 6–Aug. 18	1,310	.....	.....
1893....	July 10–Aug. 29	17,154	.....	.....	Aug. 5–Aug. 15	1,754
1894....	July 18–Aug. 23	15,525	July 25–Aug. 25	2,329	.....	.....
1895....	July 6–Aug. 16	17,874	July 26–Aug. 30	1,979	July 24–Aug. 2	1,465
1896....	July 8–Aug. 2	21,700	–Sept. 10	1,900	Aug. 3–Aug. 21	8,000
1897....	July 6–Sept. 2	26,310	July 19–Sept. 9	2,957	July 20–Aug. 21	10,016
1898....	July 13–Sept. 27	14,279	July 16–Sept. 29	4,324	July 26–Aug. 29	15,596
1899....	July 6–Sept. 1	25,018	July 19–Sept. 1	399	July 19–Aug. 25	11,223
1900....	July 7–Sept. 1	19,036	July 28–Sept. 1	343	July 23–Sept. 1	11,758

TAMGAS STREAM AND LAKE.

Annette Island on its southern side has a deep bay, 5 miles in length, which affords good anchorage in its upper part and is known as Tamgas Harbor. On the eastern side, midway the length of the bay, at Creek Point, is the mouth of a stream, a lake outlet, carrying redfish which are supplied to the cannery at Metlakahtla. Ensign Miller and Mr. Chamberlain examined this system on June 2.

The stream is over half a mile in length and at its head is 30 feet wide, 1 foot deep, and flows with a current of 2 to 3 knots, over a rocky and bowlderous bed, between moderately high banks covered with the usual growth of the country. About 200 yards from the lake the bed narrows, the stream flowing 400 yards through a ravine, at the end of which, and about 400 yards from the beach, is a barricade partially dismantled but appearing as if recently used. Tide water ascends about 200 yards from the beach. Temperature of water, June 2, 51° F.

The first lake is irregular in form, lies in a basin in a general NE. and SW. direction, and is surrounded by high snow-covered peaks, from which it receives numerous streamlets, carrying surface drainage and melting snow. It is about 2 miles long, from three-fourths to one-eighth mile in width, is apparently shallow, and elevated 75 feet above tide water. There are a few gravel beaches and the immediate shore is well wooded. At the head of the lake, in the northern corner, is the mouth of a stream which enters through a delta 200 yards long, and which is the outlet to a second lake. This stream is 600 yards long, and at the head of the delta is 10 feet wide, 1 foot deep, with a current of 3 to 4 knots. For the greater part of its length it flows over a bowlderous bed through a rocky ravine, though near the mouth it broadens over gravelly beds suitable for spawning.

The second lake is 600 yards long, 400 feet wide, and elevated 90 feet above the first lake. At its head is a feeder that may lead to a third lake, but want of facilities prevented a further examination. It is probable that salmon ascend to the second lake. The color of the water throughout the system is clear and of brownish tinge. The shores are wooded.

A hatchery site could probably be found at the head of the first lake, near the mouth of the connecting stream.

The redfish from this stream are very small and average in weight about the same as the Peter Johnson stream, viz, 3½ to 4 pounds. The stream may be rated as having a value of 10,000 redfish under average conditions.

The following table shows the catch from this stream since 1892:

Year.	Redfish.		Cohoes.		Humpbacks.	
	Dates.	No.	Dates.	No.	Dates.	No.
1892	June 28–Aug. 5	6,114				
1893	July 8–28	2,328			July 19–30	3,543
1894	July 7–Aug. 11	12,032			Aug. 6–11	2,686
1895	July 2–Aug. 9	12,357			July 17–Aug. 9	5,449
1896	July 1–Aug. 12	8,795			July 24–Aug. 18	2,982
1897	July 7–Aug. 26	13,430		40	July 21–Aug. 26	21,918
1898	July 8–Aug. 17	22,678			Aug. 9–17	4,151
1899	July 8–Aug. 29	11,026	Aug. 24–29	282	July 21–Aug. 26	29,115
1900	July 7–Sept. 1	9,517	Sept. 4	300	July 24–Sept. 1	17,743

GEORGE INLET STREAM AND LAKE.

The southern side of Revillagigedo Island is penetrated by three deep inlets, the western one of which is known as George Inlet. At its head a small cove, making to the northward immediately west of Bat Point, receives the waters of a stream, a lake outlet, which carries redfish.

This stream was examined, by a party in charge of Ensign Kempff, on June 5. It flows in a tortuous channel in a general easterly direction, at first, upon leaving the lake, through low grassy flats, while nearer the mouth it passes between rugged hills carrying in the lower half of its course numerous rapids. It is about 4 miles long, 50 feet wide, and 1½ feet deep, with a current of 3 to 4 knots. The bed throughout the rugged hills is of rock, slate, and gravel, while that portion through the flats is largely of mud. The water is clear, of brownish tinge, and on June 5 had a temperature of 59° F.

There is an island half a mile from the mouth and another the same distance from the lake. About one-fourth of a mile above the lower island a small tributary, 3½ feet wide and 4 inches deep, enters from the SW. About one-fourth of a mile above the mouth are the remains of a barricade. The log was in place, but most of the rails that had supported a lath fencing had been swept away. Some of the fencing, interwoven with wire, was near at hand.

The first lake is about one mile in length with an extreme width of two-thirds of a mile, the main axis lying in a general north-and-south direction. It lies in a low basin and has a shallow appearance, pond lilies in places extending 200 yards from the shore line. The beaches consist of rock, gravel, and mud. A conical hill, about 250 feet high, rises over a prominent point on the eastern shore. The lake has an elevation of 240 feet above tide water, and the temperature of the surface water was 59° F. on June 5.

On the eastern side, one-half mile from the extreme southern end, is a stream connecting Lake No. 1 with No. 2. It is one-half mile long, 30 feet wide, from 2 to 6 feet deep, and runs with a strong current over a gravel and mud bottom. The water has a brownish tinge, and on June 5 had a temperature of 59° F. The lakes are also connected by a slough, which enters the first lake at its southern end.

Lake No. 2 is of irregular form and has an extreme length of 1¼ miles by an extreme width of one-half mile. It has a rather shallow appearance, but is deeper apparently than the first lake. The beaches are of rock, gravel, and mud; elevation above tide water, 245 feet; temperature, June 5, 59° F.

SKETCH OF GEORGE INLET, LAKES AND STREAM, REVILLAGIGEDO ISLAND, ALASKA.

At the eastern end this lake receives from the southward the waters of a feeder, which was examined for a distance of 1½ miles to a deep pool, which had an elevation of 265 feet above tide water. This feeder is 12 feet wide, 12 inches deep, and flows with a strong current through a tortuous channel, over a gravelly bottom. It has a number of deep pools. The water has a brownish tinge, and on June 5 the temperature was 49° F.

A dead king salmon was found on the banks of the main stream, 2 miles from the mouth. It was probably a straggling fish.

George Inlet stream was fished for the Metlakahtla cannery from 1892 to 1896, and in 1900 by the Fidalgo Island Canning Co. For a number of years it was also fished by Clark & Martin. Under average conditions it may yield 6,000 redfish. The following are the only statistics obtainable:

Year.	Redfish.		Cohoes.		Humpbacks.	
	Dates.	No.	Dates.	No.	Dates.	No.
1892	June 23–July 29	9,061			July 27–Aug. 3	4,875
1893	July 7–Aug. 1	3,191			July 26–Aug. 16	9,518
1894	July 9–Aug. 15	3,219	July 11–Aug. 15	1,426	July 24–Aug. 17	11,247
1895	July 3–Aug. 6	3,787	July 17–Aug. 6	854	July 17–Aug. 6	7,905
1896	July 1–Aug. 1	2,142		531	July 21–Aug. 1	1,576
1898	July 20	225				
1900	July 8–Aug. 1	6,949	July 25–Sept. 6	2,358	July 20–Sept. 4	39,085

KAH-SHAKES STREAM AND LAKE.

About 2 miles south from the entrance to the Boca de Quadra, and opening upon the Revillagigedo Channel, is a cove named after Kah-Shakes, a chief living in the vicinity. From the northeast end of this cove a shallow tidal lagoon extends in an easterly direction for a distance of 1¼ miles. It has a width of 25 yards to 75 yards, and receives at its head the waters of a redfish stream, having a lake source which was examined by a party in charge of Lieutenant Rodman on June 6. The banks of the lagoon are rocky, well wooded, and the bottom generally muddy. Spring tides reach the head of the lagoon, which point may properly be called the mouth of the stream.

The stream proper is one-fourth mile long, 12 to 15 feet wide, 12 inches deep, and flows over a rough, rocky bottom with a slack current, forming here and there a pool. There are no decided rapids. There are many fallen trees, but no obstacle to the movement of fish in ascending. Halfway up the stream are the remains of a barricade built in the usual form of a braced log and split rails.

The lake is pipe-shaped, about 1¼ miles long in a northeasterly and southwesterly direction, expanding at its upper end into a broad basin, and receives at its eastern end, through a low, grassy flat, the main feeder. This stream is 8 feet wide, from 6 to 8 inches deep, and flows with a slack current over a gravelly bottom, which probably forms the main spawning-ground. In it and in the lake numerous small fry were noticed. The shores of the lake are low and wooded, grassy around the edges, with beaches of rock, gravel, and sand. The vegetation common to the country surrounds the system. Elevation of lake, 10 feet. Temperature of lake water, 64° F.; temperature of water of feeder, 50° F.; temperature of water in lagoon, 65° F.

This stream has been fished by the canneries at Quadra, Metlakahtla, Loring, and Ketchikan. Its value, under average conditions, may be placed at 12,000 redfish.

The following, collected from all available sources, will furnish a fair idea of the capacity of Kah-shakes stream. There are no data available for 1896:

Year.	Number of redfish.	Dates.	Year.	Number of redfish.	Dates.
1892	9,218	July 12–Aug. 17	1897	8,000	July 9–Aug. 16
1893	14,399	July 8–Aug. 28	1898	14,100	July 10–Aug. 22
1894	10,579	July 12–Aug. 16	1899	15,000	July 9–Aug. 26
1895	16,181	July 13–Aug. 15	1900	15,600	July 10–Aug. 15

Sketch of Kah-Shakes Lake and Stream, near Boca de Quadra, Alaska.

CHECATS STREAM AND LAKE.

Checats Stream empties into the southeast corner of Checats Cove, a small indentation on the eastern shore of Behm Canal, about 12 miles north of Smeaton Inlet, and was examined by a party in charge of Ensign Hepburn, on June 7. It is the outlet of a lake lying about three-fourths mile in a SSE. (mag.) direction from the mouth of the stream. The course of the stream is fairly straight from tide water to the lake. About one-fourth mile from the mouth of the stream is a small island or cluster of islands around which the water flows, the larger volume going to the westward of the island. Abreast the head of this island, on the left bank, was found a panel of rails, evidently used as a barricade when fish are running. A fallen tree spanning the stream at this point probably furnishes the support for it. Aside from this artificial obstruction the stream was found clear and clean until the lake is

KAH-SHAKES LAGOON, REVILLAGIGEDO CHANNEL, MAINLAND, SOUTHEAST ALASKA.

CHECATS STREAM, BEHM CANAL. SITE OF BARRICADE, MAINLAND, SOUTHEAST ALASKA

reached. There are no falls, cascades, or heavy rapids, although half the length of the stream, from the mouth up, might be called a continuous rapid. The water is of good depth and the current not strong enough to prevent the ascent of salmon. The bottom is stony, with bowlders in the rapid parts; near the lake, where the current

Sketch of Checats Lake and Stream, east side of Behm Canal, Alaska.

is sluggish, there are some pebbly parts, but generally it is of mud or sand, with much water-logged timber and bark. The water has a brownish tinge, and on June 14 had a temperature of 55° F. The banks are steep and thickly wooded with spruce, pine, devil's club, and berry bushes, with an unusual number of large trees. Tide water

extends 150 yards upstream from the low-water mouth. The average width of the outlet is 40 feet, depth 18 inches, and current 3 knots.

The lake is of an irregular, hour-glass shape, about 1½ miles long, and from one-fourth to one-half mile broad. It has four well-defined feeders. The shores, except for a short stretch near the middle of the eastern side and at the southern end, are very steep and thickly wooded, and drop off into deep water a few feet from the beach, except at the mouths of the feeders and on the northwestern end, where there are sandy shoals. Across the outlet is a large drift of big trees, but the water here is several feet deep and fish can readily pass underneath. The bottom, where it can be seen, is generally of sand, sometimes of pebbles or rock, and at the southern end, where a small feeder enters, of mud with water-logged bark. The temperature of the water was 52° F. The lake has an elevation above sea level of 60 feet.

The principal feeder enters on the northeastern side about one-fourth mile from the outlet. It is a stream 30 feet wide, 12 inches deep, with a current of 4½ knots, and flows over a stony and pebbly bottom in a general southwesterly direction. The water is dark and clear, a little lighter in shade than the lake water, and has a temperature of 49° F. About 200 yards from the mouth of this feeder there are heavy falls, which, it is believed, the salmon can not pass.

The next feeder in point of size enters the lake at a point about 400 yards south of the mouth of the stream just described, near the narrowest part of the lake. This stream has two mouths, forming a delta of considerable extent. The division of the main stream occurs about 300 yards from the lake shore. It flows in a tortuous channel through a rather low country in a general westerly direction. Half a mile from the lake the ground rises sharply, and here is a series of cascades and falls insurmountable for any fish, the water in places spreading out and rushing over huge, smooth, sloping rocks with great velocity and a depth of only one or two inches for many feet. The water is very clear and cold, temperature 39° F., and apparently comes from the melting snows on the mountains. The average width of this stream is 25 feet, depth 10 inches, and current 4 knots; bottom stony and gravelly. In late summer this volume must be very much reduced.

A small feeder enters the lake on the southeastern side. It is inconsiderable in size and is apparently formed by seepage from the hills.

Another small feeder enters at the head of the lake in its extreme southern part. It is a small stream flowing through a narrow valley, low and flat near the lake but rising to an altitude of 250 feet within 1 mile. Temperature of the water, 52°.

A few trout or, possibly, young salmon, about 4 inches long, were seen near the drift of logs around the outlet.

A good site for a hatchery could be found at the mouth of either of the two feeders first mentioned. The ground around the mouth of the second stream is better adapted for building purposes, and the supply of water there is at present ample, but this supply must be greatly reduced at times if, as is supposed, the stream is only the result of melting snow. The volume of the first feeder is greater, and the water in it has the appearance of being that of a lake outlet.

Checats Stream was referred to in my report for 1897, page 100, and was then fished by canneries at Loring and Yes Bay. Since 1897 it has been fished by Loring only. Under average conditions, it may yield 12,000 to 15,000 redfish per season.

CANNERY OF ALASKA PACKERS ASSOCIATION, POINT HIGHFIELD, WRANGELL ISLAND, SOUTHEAST ALASKA.

KUNK LAKE, LOOKING UP, ETOLIN ISLAND, SOUTHEAST ALASKA.

The following are the only statistics that can be obtained of Checats Stream:

Year.	Species.	Total number.	Average number per case.	Season of run.	Canneries to which consigned.
1895	Redfish	9,680			Yes Bay.
1896	Redfish	10,712		July 12–Aug. 12	Yes Bay and Loring.
	Redfish	15,229	9	July 10–Aug. 28	Do.
1897	Cohoes	489	6	Aug. 26–Sept. 1	Yes Bay.
	Humpbacks	20,682	15	July 21–Aug. 15	Yes Bay and Loring.
	Dog salmon	821	6	July 23–Aug. 2	Yes Bay.

Year.	Redfish dates.	No.	Coho dates.	No.	Humpback dates.	No.
1898	July 13–Aug. 17	19,821	Sept. 6–Sept. 10	2,157	July 13–Aug. 26	24,168
1899	July 13–Sept. 2	11,816	Aug. 9–Sept. 2	6,071	July 17–Aug. 20	32,382
1900	July 13–Aug. 15	4,165	July 26–Sept. 7	3,994	July 15–Aug. 16	13,591

KUNK (KONKE) STREAM AND LAKE.

On the east side of Etolin Island, about midway between Chichagof Pass and Anita Bay and opposite a point projecting from Wrangell Island, is a small stream which carries redfish and discharges its waters into Zimovia Strait. It was examined by a party in charge of Ensign Miller on June 11.

This stream is the outlet to a lake lying about 1½ miles WSW. from the mouth. It is 20 feet wide and 12 inches deep, with a strong current and a temperature, June 11, of 52° F. It flows over a rocky and bowlderous bed having at intervals small areas of gravel and sand. About 150 yards from tide water are the remains of a barricade and three-fourths of a mile from the same point, on the left bank, a tributary enters; this is about one-third the size of the main stream and has an elevation at the junction of 110 feet above tide water and a temperature, on June 11, of 45° F. From this point to the lower arm of the lake, a distance of three-fourths of a mile, the main stream flows through a deep ravine in which there is a series of rapids; the greatest fall is about 7 feet, but is much broken and presents no serious obstacle to the ascent of salmon. As the head is reached the stream widens into the lower arm of the lake, which is 1½ miles long and 300 yards wide, with an elevation above tide water of 270 feet and a temperature of 58° F.; this arm narrows at the head and then opens upon the main body of water.

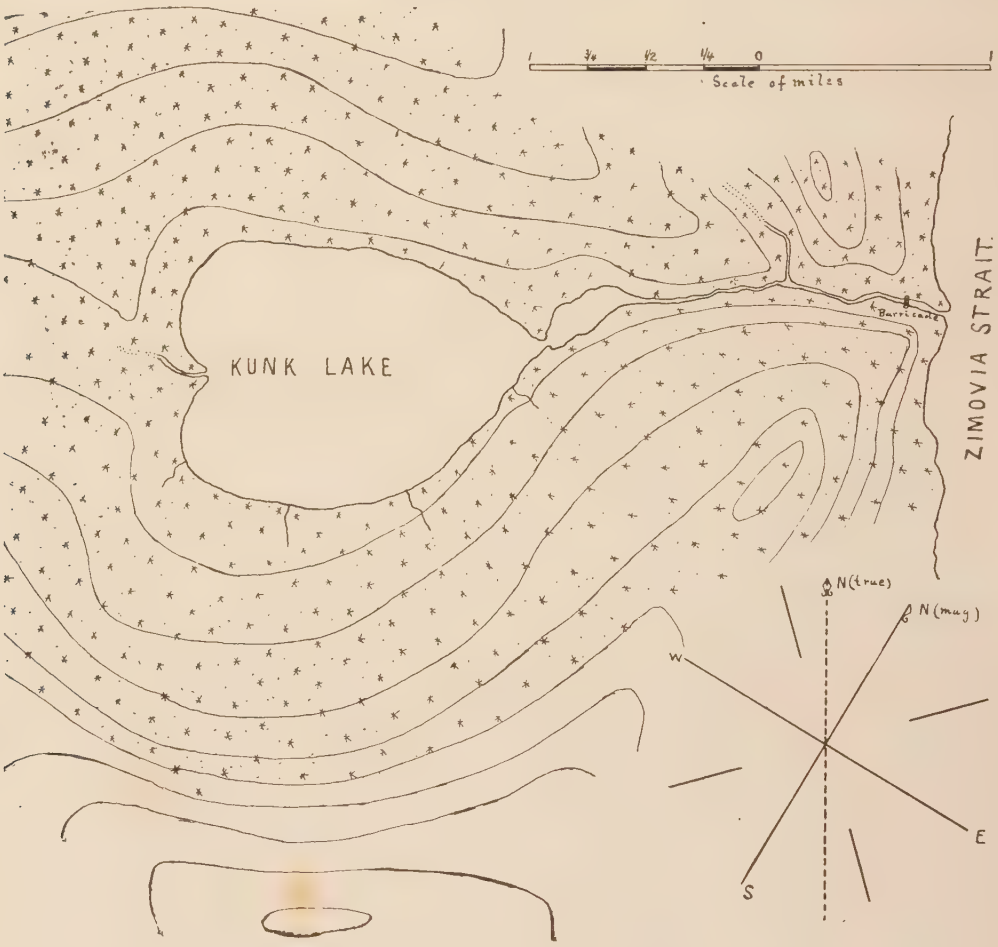
The main lake is heart-shaped, 1½ miles long by about the same width. At the head of the lake, the western end, is the main feeder, which flows through a narrow valley and is about 18 feet wide, 5 inches deep, and has a 3 to 4 knot current; the temperature, June 11, was 45° F.

On the southern side are four small streams together carrying a volume of water into the lake equal to that of the main feeder and draining the melting snow from the high mountains on that side. The vegetation around the streams and lake is dense and consists of large trees and the usual scrub growth. At a few points on the upper end of the lake there are small grassy flats. A few pond lilies were noticed near the shore and numerous small fry were seen, probably salmon. The level of the lake seemed to be at its highest point, and, from the appearance of the shore line, it probably falls several feet during a dry season. Near the mouth of the large feeder a site for a small hatchery might be found.

There are no records available for Kunk stream. It is one of the small redfish streams and yields 2,000 to 5,000 of that species during a season. It has been fished by the Wrangell cannery and on their books is classed as transient.

SALMON BAY STREAM AND LAKE

Salmon Bay is on the northeastern end of Prince of Wales Island near the junction of Clarence and Sumner straits and about 7 miles to the eastward of Red



Sketch of Kunk Lake and Stream, Etolin Island, Alaska.

Bay, and receives at its head the waters of a redfish stream, which is a lake outlet. This stream was examined during the season of 1900 for a distance of 3½ miles, but unfavorable conditions prevented the continuation of the work at that time, and it was again visited this year. A description of the lower part of this stream is contained in my report for 1900, and from that point is continued here.

It was examined by a party in charge of Ensign Kempff, who found that at the point "F" the stream forked, the eastern branch being the outlet to the lake. It

RACKS USED TO BARRICADE KUSHNEAHIN STREAM, KUPREANOF ISLAND, SOUTHEAST ALASKA.

CANNERY OF ALASKA PACKERS ASSOCIATION, LORING, NAHA BAY, REVILLAGIGEDO ISLAND, SOUTHEAST ALASKA.

flows in a general northerly direction over a muddy bottom between low grassy banks which become wooded and rocky as the forks are approached. Three-fourths of a mile above the forks the stream widens to about 50 yards and seems deep-flowing, with little current. The water has a brownish tinge, and on June 14 had a temperature of 61° F. There are no obstructions of any kind in the upper part of the stream.

Near the source it widens into a shallow lake with a mud bottom and covered

Sketch of Salmon Bay, Lake, and Stream, Prince of Wales Island, Alaska.

with pond lilies. This small lake lies in a general NNE. and SSW. direction, and is about 1 mile long with an arm, rather less than one-half mile in length, extending to the NW. Near the center is a large grassy islet. The banks, which are low and grassy, have wooded flats extending back from them. The elevation is 145 feet; temperature of the water, 61° F.

To the southward, and connected with the small mud lake by a short passage, is the main lake, which lies in a general north-and-south direction and is about 3 miles long with an extreme width of three-fourths of a mile. The banks slope from the wooded hills to the rocky beaches, and the lake is apparently quite deep.

For want of facilities the lake could not be examined in its entire length, but no feeders were observed in its northern half. An Indian who hunts the region during the winter stated that several feeders of considerable size entered the lake near the southern end, and it is probable that these feeders form the redfish spawning-ground.

The available statistics to 1900 are given in my 1900 report, page 267.

KUSHNEAHIN STREAM AND LAKE.

On the southwestern end of Kupreanof Island and a mile NNW. from Point Barrie is a small rocky indentation which receives the waters of a redfish stream. The mouth lies opposite a small wooded islet which is joined to the main shore on its northern side by a line of kelp-covered sunken reefs. This stream, known as Kushneahin, is referred to in my 1897 report, p. 108. As it is in an exposed and dangerous locality the conditions did not at that time, nor last year, permit an examination, but it was examined on June 14 by a party in charge of Lieutenant Rodman.

Kushneahin Stream is a lake outlet and along its bed is 8 miles in length, though in a straight line the distance to the lake is 25 per cent less; the general direction of the flow is southwest. At the mouth, where it is spread out and the current sluggish, the stream is about 40 feet wide, from 1 to 12 inches in depth, and temperature of water 53° F. Two miles above, where it is contracted in a narrow channel of uniform depth, it is 14 feet wide and 3 inches deep.

About 4 miles from the mouth is a broken fall 8 to 10 feet high, which, however, forms no serious obstacle to the ascent of fish. From the sea to this point, which is 245 feet above tide water, the bed rises gradually and is rocky and stony, with a little gravel along the banks. The latter are generally low with occasional bluffs rising from 10 to 100 feet. One mile below the falls the stream flows through a cut about 150 yards long and 30 to 40 feet wide, the water lying in deep pools between the bluffs, which are from 20 to 70 feet high. Except the falls there are no strong rapids in the stream. In the upper half the stream flows through a low flat country with a sluggish current over a gravelly bottom. The hills in this section recede fully a mile. Half a mile above the falls it receives from the northward the main tributary which rises in the hills forming the northern part of a valley. At the mouth it is 6 feet wide, 3 inches deep, and so far as examined it flows over a rocky and gravelly bed. The water is clear, and on June 14 had a temperature of 46° F. The water in the main stream above the principal tributary is tinged dark brown.

All other tributaries are insignificant, though two on the left bank may afford spawning-beds for humpback salmon. The channel of the main stream below the falls follows gentle curves, while above it is more tortuous and meandering, winding through low, extensive flats or tundra. Except over the open flats and tundra, the vegetation is of the usual type, heavy woodland and dense undergrowth.

On the bank and 100 yards above tide water, which ascends 200 to 300 yards from the mouth, there were 24 frames, 7½ feet by 4 feet, in good condition, neatly piled, with some old webbing near by, evidently to be used in barricading the stream

SUMNER STRAIT

SKETCH OF KUSHNEAHIN LAKE AND STREAM, KUPREANOF ISLAND, ALASKA.

Bull. U. S. F. C. 1901. (To face page 368.)

as soon as the run set in; 50 yards above this, in the stream, is a log crib, ballasted with stone and probably used in the barricade. The frames were burned.

Numerous small fry were seen in the pools.

The lake is about three-fourths of a mile long by one-eighth to one-fourth of a mile wide and lies with the major axis in a north-and-south direction. The western shore is low with scattering trees, while the eastern shore is high and densely wooded. The lake appears shallow, an abundance of pond lilies cropping out, especially around the lower end. The beaches, and bottom where it could be seen, are stony, with gravel and some mud. The elevation is 315 feet. Temperature of water June 14, 64° F. A small sluggish stream apparently enters the upper end, but for lack of facilities a proper examination could not be made. It is believed the locality would not afford a good hatchery site.

There are no stream data available for Kushneahin. Formerly it was fished at times by the cannery at Redfish Bay. It is believed the stream is good for 10,000 redfish under average conditions.

POINT BARRIE SALTERY.

About one-fourth of a mile below the mouth of the stream (Kushneahin) is the Point Barrie saltery, formerly operated by Mr. Cyrus Orr. It is located on a small indentation and consists of the saltery building, store, dwelling, and wharf. The place was closed at the time of our visit. In the saltery proper were 15 tanks of 20 barrels capacity each, all clean and in good condition, a quantity of salt, a number of casks, barrels, tubs, and an outfit of nets, webbing, etc.

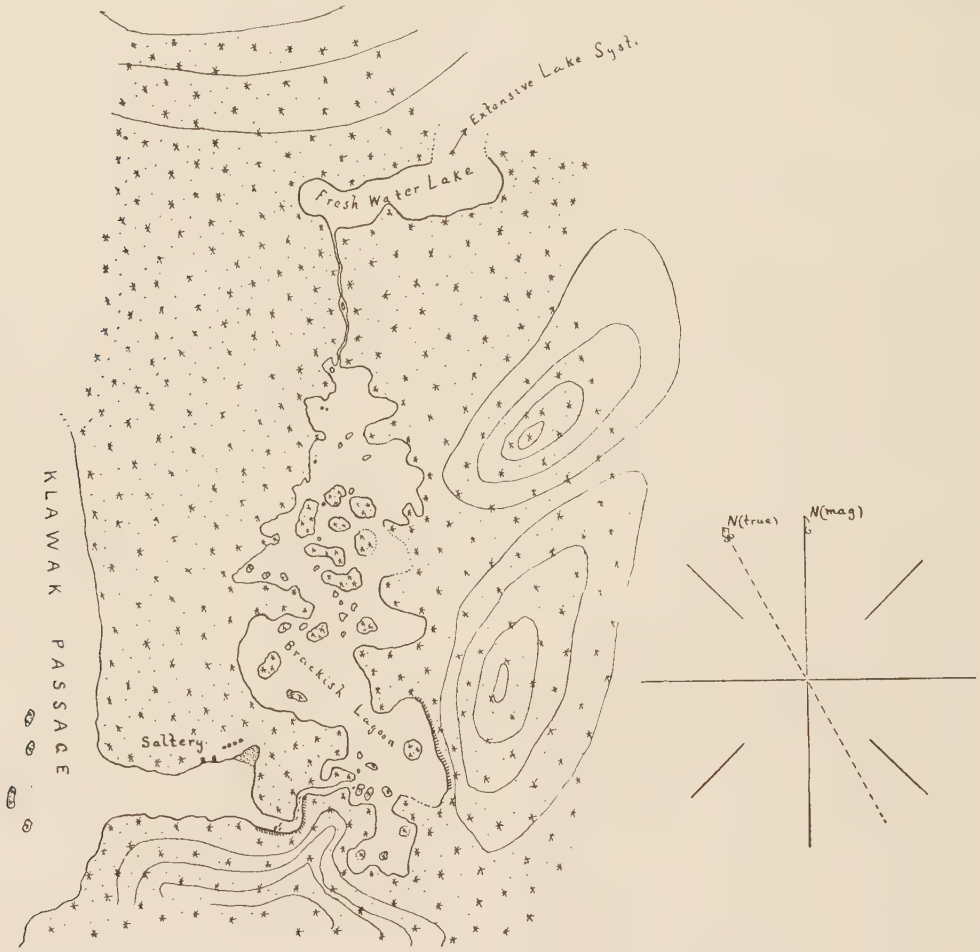
SAR-KAR STREAM AND LAKE.

On the eastern side of Klawak Passage, western side of Prince of Wales Island, and about 20 miles from Shakan village, is a small inlet one mile long and about three-eighths mile wide, with a general east and west (mag.) direction. On the northern side of this inlet, near the eastern end, are located the Brockman saltery and a small Indian village. A narrow, crooked, salt-water strait, the outlet of a brackish lagoon, enters the inlet at the southeastern end. From its mouth this outlet extends ESE. (mag.) for three-eighths mile, turns sharply to the northward one-fourth mile, and then, with another turn to the eastward, enters the brackish lagoon. The southern shore, as far as the lagoon and a little inside, is bluff, the northern shore low. In the stretch from the lagoon entrance to the second turn are large rocks.

About three-fourths of the distance from the entrance to the first turn is the piling for a trap which extends entirely across the strait. The saltery owner stated that this trap had not been used for four years. From the surrounding conditions it is believed that fishing by any other means would be very expensive.

The brackish lagoon extends in a north (mag.) direction about 3 miles from the strait and three-fourths of a mile south from it. The shores are low and flat except for two small hills on the east and a part of the southern shore. The western shore was followed from the strait northward to the mouth of the stream and the sketch shows its general outline, but the lagoon is so filled with islands and the channels between are so narrow that the view is restricted in every direction, and what is sketched as the eastern shore of the lagoon may be additional islands. The shores are rocky, apparently limestone, low and flat, covered with spruce and hemlock, and

in almost every cove are grassy flats. Temperature of water, 66° F. The lagoon is 2 to 4 feet in depth except near the middle channels, where it appears quite deep. At its northern end a small fresh-water stream enters, which is the outlet of a chain of lakes lying to the northward. From its mouth it extends in a general northerly direction for a distance of about 1 mile, with a gently winding course. Two hundred yards from the lagoon is a small cascade. The banks are generally low and flat near the mouth, rising gradually toward the lake, where the stream



Sketch of Sar-kar Lake and Stream, Klawak Passage, Prince of Wales Island.

flows between low bluffs. The bottom is stony and pebbly, gravelly sometimes in the deeper pools, and the water dark brown and not very clear.

From the head of the stream the first lake extends to the ENE., apparently for about one mile, with a width of from one-fourth to one-half mile. The bottom is gravelly, the shores low and well wooded with spruce, hemlock, and berry bushes. Elevation, 40 feet; temperature, 60° F. The Indians state that there is a system of

lakes and sloughs extending a very long distance, and that there is another outlet to this system on the other side of the island. It is said that the salmon do not spawn in the lower but ascend to the upper series of lakes. Redfish were just beginning to run and a few were seen jumping in the lagoon outlet.

Sar-Kar stream is fished by Mr. Fred Brockman, who has lived here many years. All the fish that are called for are sold fresh to the cannery at Klawak, and the remainder are salted. This stream was referred to in my report of 1897, p. 116, to which further reference is made, but it was not visited at that time. The examination was made by Ensign Hepburn on June 15 and 16.

The value of this stream, under average conditions, is from 18,000 to 20,000 redfish per season. The following is the available stream record of fish taken:

Year.	Redfish.		Cohoes.	
	Dates.	Number.	Dates.	Number.
1887	July 3 to Aug. 4	6,476		
1888	June 28 to July 11	6,834	Aug. 7 to Sept. 8	14,528
1889	July 3 to Aug. 30	11,555		
1890	July 6 to Aug. 16	16,267	July 25 to Sept. 6	15,331
1891	June 23 to Aug. 21	35,033	Aug. 19 to Sept. 10	9,033
1892	June 24 to Aug. 19	24,024	July 27 to August 23	4,700
1893	June 24 to July 30	9,797		
1894	July 7 to Aug. 2	12,678		
1895	June 26 to Aug. 31	11,636	July 21 to Sept. 4	3,830
1896	June 18 to Aug. 2	20,480	Aug. 2 to Sept. 2	9,643
1897	June 25 to Aug. 17	21,667	Aug. 17 to Sept. 1	8,207
1898	June 20 to Aug. 18	24,974	Aug. 16 to Sept. 6	10,423
1899	June 15 to Aug. 10	36,000	Aug. 15 to Sept. 8	7,000
1900	June 19 to Aug. 4	26,021	Aug. 14 to Sept. 16	12,000

Average weight of redfish, 5½ pounds; of cohoes, 9 pounds; of humpbacks, 3¼ pounds.

FRED BROCKMAN SALTERY.

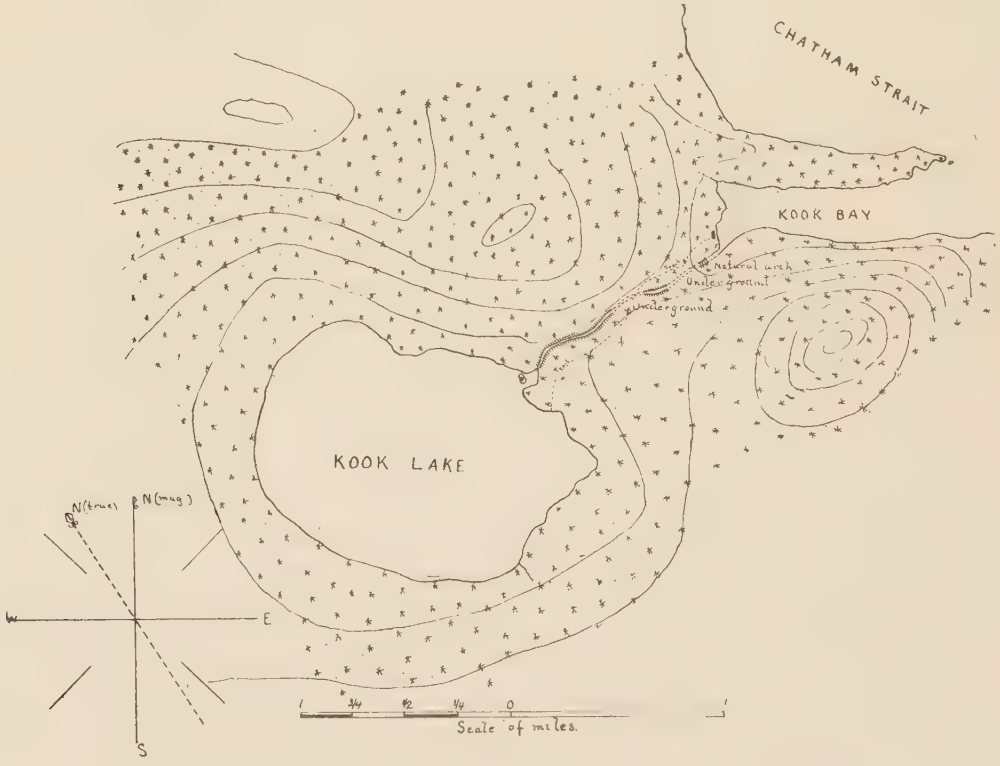
This saltery is located on the northern side of Sar-Kar Inlet and consists of two small buildings on piling, each 25 feet by 40 feet, and a cooper shop. There are 14 tanks of 20 barrels capacity each. All the redfish and most of the cohoes are sold fresh to the Klawak cannery, which calls on alternate days, so that all the salting done here in recent years has been in cohoes and humpbacks. It is estimated that the saltery has a capacity of 200 half-barrels of redfish, 360 half-barrels of cohoes, and 120 half-barrels of humpbacks, but this total has never been reached here. Transportation is through the Klawak cannery. The salting from 1889 to 1898 has averaged less than 100 barrels a year. Salted 50 half-barrels of whole humpbacks and 150 half-barrels of humpback bellies in 1898; 250 half-barrels of humpback bellies in 1899, and 250 half-barrels of humpback bellies in 1900.

Most of the humpbacks used at the saltery are taken at a stream about 7 miles to the northward of Sar-Kar, on Kosciusko Island, known as Tok-Hene, which has a capacity of about 80,000 humpbacks. A few cohoes are obtained from a stream known as Sar-Hene, on Klawak Passage, about 8 miles below the saltery.

KOOK (BASKET) BAY, STREAM, AND LAKE.

Kook, or Basket, Bay is a narrow indentation or inlet about 1 mile in length, extending into the eastern side of Chichagof Island and opening upon Chatham Strait about 11 miles to the northward of Point Hayes. At the head of the bay is the mouth of a stream, the outlet to a lake, which carries a few redfish. It was examined by Ensign Miller on June 19. This stream flows from the lake in a general ENE. direc-

tion through a heavily wooded country, and is about a mile long, with a width at the head of 30 feet, depth 1 foot, and a very strong current. Commencing at the lake, from which the head of the stream is screened by a small wooded islet, it flows over a bowlder bed through a deep ravine for one-half mile, when the water disappears in the face of a rock mass about 60 feet high, which appears to be thrown across the gulch. Three hundred yards beyond the water reappears and flows through a chasm for an equal distance, after which it is again lost in a subterranean channel for another 300 yards. At the point where it again emerges the channel is choked by massive bowlders, and on the adjoining bank were found a number of the slat frames commonly used for barricading. From here the stream flows with a sluggish current for 100



Sketch of Kook Lake and Stream (Basket) Chichagof Island, Alaska.

yards through a deep cut having nearly perpendicular rock walls, and then for 50 yards under a fine arch rock, the top of which is about 4 feet above the highest tides; 50 yards beyond it enters the bay. Temperature of water June 19, 47° F.

The lake is 35 feet above tide water. It is round in shape, about 1½ miles long by 1 mile wide, and lying in a heavily wooded basin, having at the western end a wide depression through which the main feeder probably flows.

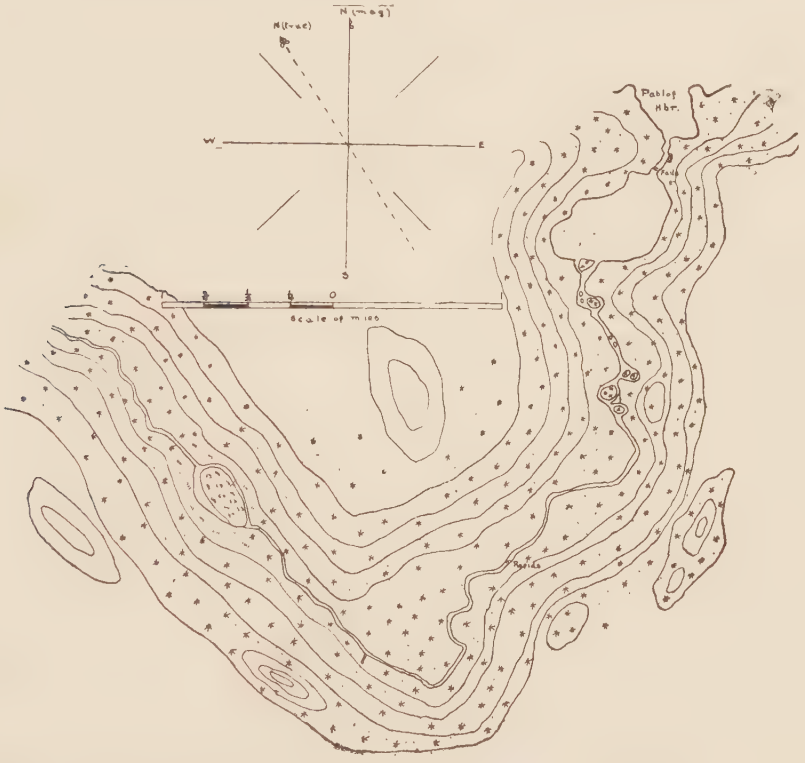
Around the flats at the mouth of the stream the Indians had planted some heavy wooden posts, though for what purpose could not be learned. As they were removed upon the approach of the boat, it is possible that a trap was in course of construction.

The only record available for this stream is from the books of the Baranof Packing Company, namely: In 1896, 21,175 redfish were taken July 12 to July 27.

FRESHWATER BAY, STREAM, AND LAKE.

On the eastern side of Chichagof Island, about 12 miles below Point Augusta, a deep inlet makes in to the westward known as Freshwater Bay. On the southern side of this bay, 4 miles within the southern entrance point (East Point), is a cove known as Pablof Harbor, which affords a good anchorage, and receives at its head the waters of a stream carrying redfish, and known among fishermen as the Freshwater Bay stream. It was examined by a party in charge of Ensign Kempff on June 20.

Near the mouth on the southern side is the old site of the cannery of the Astoria and Alaska Packing Company, which made a pack in 1889 and then moved to the South Bay of Pillars, where it was destroyed by fire in 1892.



Sketch of Stream, Lake, and Feeder, Pablof Harbor, Chichagof Island, Alaska.

Freshwater Bay stream, the outlet to a lake, is less than one-fourth mile long, 100 feet wide, 9 inches deep, and flows with a strong current over a rocky and gravelly bottom, between rocky, well-wooded banks. Just without the lake the water flows over a broken fall, 10 feet high, but so stepped that fish may easily ascend at high water. There are no barricades. Temperature of water, 43° F.

The lake is three-fourths of a mile long and one-half of a mile wide, with the major axis NE. by E. and SW. by W. The shores are low, grassy in places, with heavily wooded areas in the background; the beaches are muddy, and the body of water seems moderately deep. Temperature of water near the shore, 45° F. Elevation, 20 feet.

A large feeder, which enters the lake at the southern end, around an islet in its mouth, was examined for a distance of 5½ miles.

It flows in a winding channel, through a gradually rising country, in two general directions from the highest point reached, first to the SE. and then to the NNE. At a point measured it was 100 feet wide, 9 inches deep, with a strong current. In the lower course are numerous wooded islands, and about 4 miles from the mouth is an extensive flat, the stream at this point flowing around a low island, nearly one-half mile long. The banks here are grassy, with much elder, while in other places they are heavily wooded. Except through the flats the stream bed is rocky, with intervals of gravel patches. The water has the brownish tinge usual to lake water in Southeast Alaska, and had a temperature of 40° F. Elevation of highest point reached, 180 feet. At this point there were no signs of a second lake; later, however, some Indians stated that there was a second lake beyond, to which salmon ascended. Inaccessibility would make the second lake unsuitable as a hatchery site, while on the first lake difficulty would probably be encountered in securing mature fish and pure water for hatchery purposes.

There is no record available for this stream, but from the best authorities it is stated that it will produce 50,000 redfish per season under good conditions.

BARTLETT BAY, STREAM, AND LAKE.

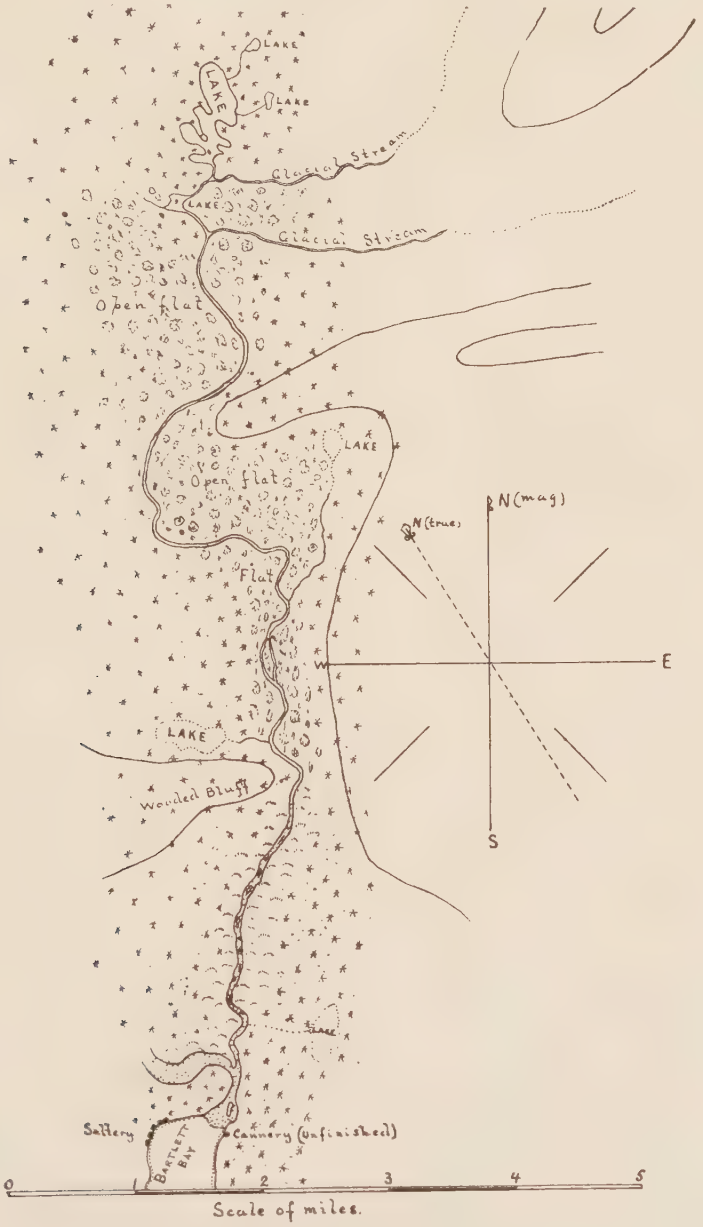
Bartlett Bay or Cove is on the eastern side of Glacier Bay, about 4 miles to the northward of Point Adolphus, and is formed by the southernmost of the Beardslee Islands and a projection from the mainland. The head of the bay receives the main body of water flowing from a redfish stream, a portion of which, however, empties into Glacier Bay to the northward of the Beardslee Islands. The stream was examined by a party in charge of Lieutenant Rodman on June 26.

The main supply of water in the stream comes from two branches which flow from glaciers in the mountain ranges to the eastward, the water received from streams having a lake source forming only a small portion. The stream is about 9 miles long from its mouth to the upper lake, the width varying from 15 yards in the upper reaches to 150 yards in the lower, and the depth from a few inches to several feet; the general direction of the flow is south. The stream bed is gravel, sand, mud, and bowlders. As far as the wooded bluff, which is reached by high-water tides, and where the first rapids begin, the stream flows through low grass-covered flats with the tree line receding for one-fourth mile. In this section there are numerous sand bars, mud flats, islands, and pools. From the bluff to the lake the rapids are frequent, but not very strong, and the stream meanders through low flats covered with pussy willow and cottonwood, with scattering spruce, hemlock, alders, and elders. Over the flats are great areas of strawberries, which are sought by the Indians during the latter part of July and August.

Three-fourths of a mile above the bluff is an island about one-fourth mile long, and in the first bend below is a V-shaped runway in which traps were formerly used. There is no evidence of barricading, though the stream could easily be closed by nets at the head of tide water.

Immediately above the wooded bluff a small tributary enters from the westward, 2 feet wide, 4 inches deep, temperature 56° F., which is said to drain a small lake about half a mile long. One-half mile above the large island is another tributary,

flowing from the eastward, which is 6 feet wide, 8 inches deep, temperature 56° F., and also said to drain a lake. The sources of both these tributaries are reported to furnish a moderate area of spawning-ground for redfish.



Sketch of Bartlett Bay, Lake, and Stream, Glacier Bay, Alaska.

The water of the main stream is glacial in appearance, and at a point measured was 48 feet wide, 20 inches deep, current strong. Temperature of the water at the mouth, 46° F.; 5 miles above, 40° F.; and below the lake outlet, 39° F.

The main lake sought by redfish lies a short distance to the northward of the mouth of the glacial streams which furnish the main body of water. The lake lies in a low basin at the foot of a high mountain system, at an elevation of 95 feet above tide water. The temperature of the surface water was 56° F. It is an irregularly shaped body of water, less than a mile in length, lying in a general north-and-south direction. The bottom is sand and gravel. The banks are heavily wooded with the usual growth, and on the water near the shore are large areas of a mossy scum. It is said the lake receives two small feeders, the outlets to two small lakes, but there are no large feeders. A number of small fry were seen in the lake.

Immediately below the main lake, and between the mouths of the glacial streams, is a small lake or pond in which it is probable that some fish spawn.

There are no available data from which the value of this stream can be estimated; it is said to vary considerably. During a good season it may yield 50,000 redfish.

BARTLETT BAY SALTERY AND CANNERY.

On the northern side of Bartlett Bay, about half a mile from the mouth of the stream, is a saltery which was owned by the Icy Strait Packing Company and operated by that organization in 1900. As a branch of their Petersburg cannery, which was acquired by the Pacific Packing and Navigation Company this spring, it is understood that the Bartlett Bay property was included in the transfer. At the date of our visit, June 25, it was stated that the saltery would not be operated during the season, but that all fish taken would be transported by steam tenders to the new cannery of the Chatham Straits Packing Company at Sitkoh Bay. The saltery has 12 tanks of 12 barrels capacity each. A crew of 8 men, with 2 boats, arrived on the ground June 20, and to the 25th had taken 80 redfish.

During the season of 1900 the Icy Strait Packing Company erected a cannery building on the southeastern shore of Bartlett Bay, opposite the saltery, expecting to install machinery in time to operate it during 1901. At the time of our visit the plant consisted of a simple cannery building, 150 feet long, projecting on piles over the water. No machinery had been installed, and it was stated that no additions would be made during the season. Like the saltery, it is believed to have been acquired by the new combine.

DUNDAS BAY STREAM.

The Western Fisheries Company, located at Dundas Bay, obtains some redfish from around the mouth of a stream at the northern end of Dundas Bay, the value of which is unknown. An examination of the lower course of this stream was made by Ensign Hepburn on June 28.

A broad, flat valley makes to the northward of Dundas Bay which is drained by two streams, one a glacial stream with a width varying between 60 and 100 yards, an average depth of 2 feet, and a strong current flowing in a general ESE. direction; the other is a much smaller stream, the outlet of a lake lying about 10 miles NNW. from the center of the mouth of the valley. Three miles from the northern shore of Dundas Bay these streams join at a point where the two parts of the glacial stream unite again after flowing around a large island. From this point of junction the two streams flow SSE. (mag.) for about a mile between well-defined banks and then spread out over a large triangular gravel flat about 2 miles long and extending across the

valley. Through this loose gravel the stream is continually cutting new channels, making islands and sweeping them away. For this reason it is very difficult to carry a boat upstream. Even when the depth continues sufficient the current is too strong to pull against, and tracking becomes necessary, which is very trying in the icy glacial waters. Above the gravel flats the banks are steep, from 6 to 12 feet high, muddy, covered with a dense growth of scrub alder and berry bushes, and the current in places runs fully 6 knots. As far as could be seen, the valley continued broad and flat for a distance of at least 8 miles. The mountains on each side appear moderately well wooded with spruce and hemlock, while throughout the center of the valley, except near the streams, are many sandy and grassy flats. No fish were seen,

Sketch showing position of Dundas Bay cannery and stream, Icy Strait, Alaska.

nor were there any obstructions. Tide water extends about a mile upstream from the bay shore.

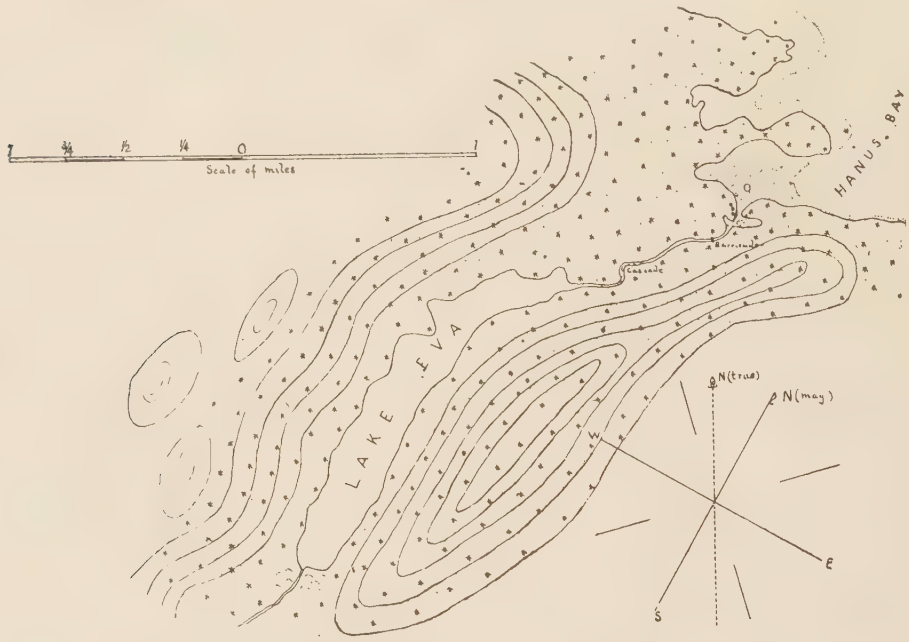
WESTERN FISHERIES COMPANY, DUNDAS BAY.

The cannery of this company, referred to in my report of 1900, is on the western side of Dundas Bay, about 4 miles within the entrance. With the machinery installed this year it was claimed to have a capacity of 500 cases per diem. Fish are pewed from boats to hand carts and wheeled up an inclined plane to the fish-house at the seaward end of the cannery. The transportation is by regular line of freight steamers. The localities fished for redfish in 1900 and 1901 were Bartlett Bay, Dundas Bay, Taylor Bay, Glacier Bay, Surge Bay, Dry Bay (Alsek River Delta), Excursion Inlet, Cape Spencer, Hocktaheine, and Takanis; humpbacks were obtained in Mud Bay and

Port Althorp. The redfish value of these localities is unknown, but, excepting the Alsek, is not believed to be large. In 1900 this cannery took from the various localities 67,000 redfish, but as fishing was to be carried on more vigorously in 1901 better results were expected.

HANUS BAY, STREAM, AND LAKE.

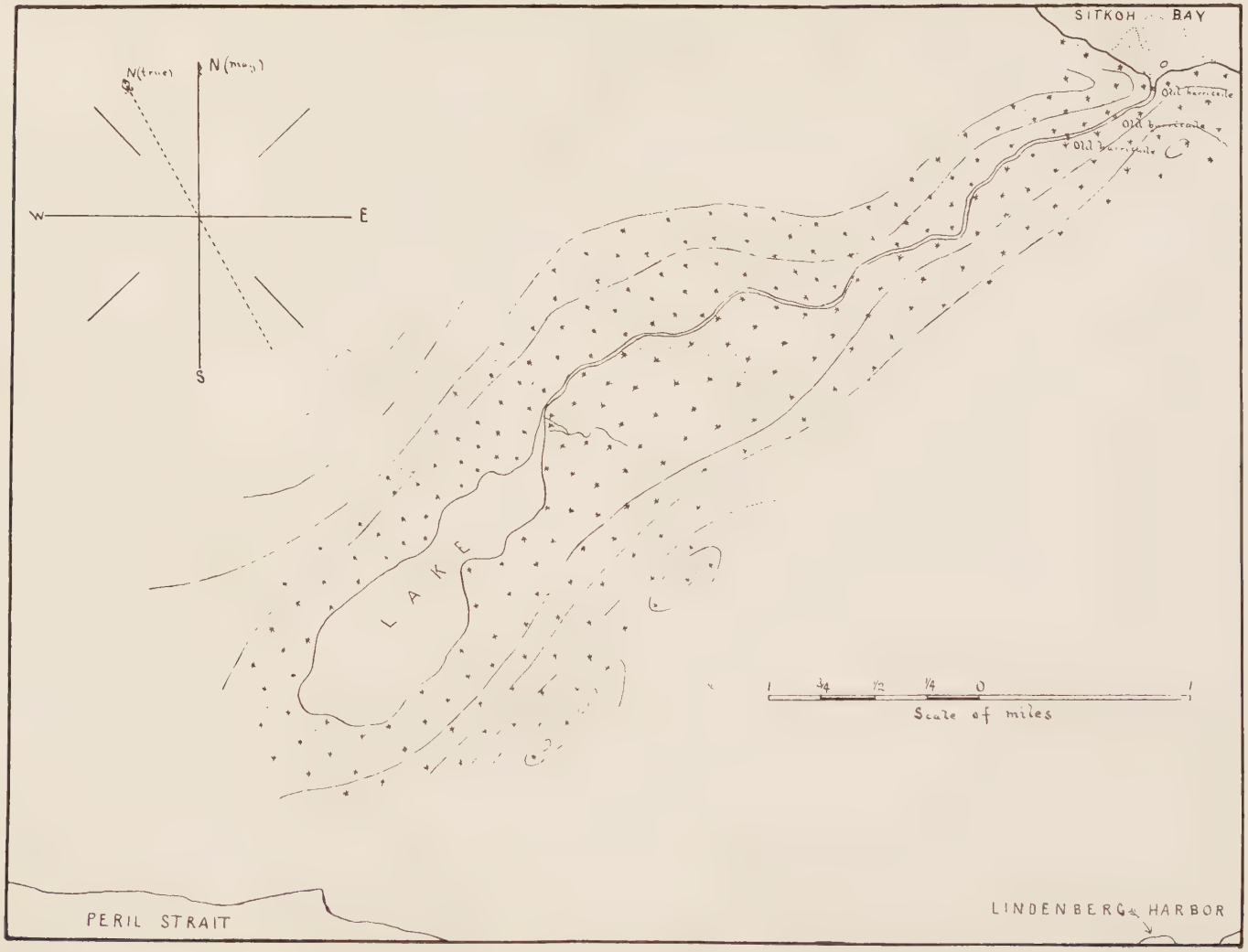
In the eastern part of Peril Straits, opposite Lindenburg Head, on the Baranof Island shore, is a wide bight, known as Hanus Bay, which receives, in its shallow southwestern arm, the waters of a stream, a lake outlet, carrying a few redfish. This system was examined by a party in charge of Lieutenant Rodman, on August 5.



Sketch of Hanus Bay, Lake, and Stream, Baranof Island, Alaska.

From the lake to tide water the stream is about three-fourths mile long, and at a point measured was 45 feet wide, 12 inches deep, flowing in a general northeasterly direction, with a strong current. In the upper reaches the stream bed is solid rock, and in the lower portion is of rock, sand, and gravel. The stream proper empties into a small tidal basin, about 350 yards by 100 yards, which leads by a narrow passage to Hanus Bay. Spring tides ascend to the rapids about 200 yards above the tidal basin. At this point are the remains of a barricade; the framework is standing, but the slats have been removed. About one-third mile above the barricade is a series of rapids, or cascades, having a drop of about 10 feet, which, however, offer no serious obstruction to the ascent of salmon. Above this the stream makes a double bend and one-fourth mile beyond emerges from the lake. Between the rapids the stream varies from 50 to 150 feet in width, from 4 inches to 3 feet in depth, and flows with a slack current over a sandy bottom. The water is clear, rather lighter in color than most lake outlets, and had a temperature of 53° F.

PLATE XLII.



SKETCH OF SITKOH BAY, STREAM, AND LAKE, CHICHAGOF ISLAND, ALASKA.

Bull. U. S. F. C. 1901. (To face page 378.)

Between the barricade and the cascade the banks of the stream are low and marshy; in other places they are high. The vegetation is that usual in the forests of Southeast Alaska and is very dense. Back from the stream on both sides are high hills; those on the eastern side come closer to the stream and continue to the head of the lake. On the western side, between the lake and tide water, is quite an extensive flat. The lake is about 15 feet above high water, is slightly crescent-shaped, extending in a general northeast and southwest direction for about 1¾ miles, and has in no place a greater width than one-fourth mile. It is apparently deep, except near the outlet, and the water is clear. The main feeder is at the head and appears to carry a large body of water, much of which is probably received from the melting snows of the surrounding mountains. A good hatchery site might be obtained on this feeder.

The run of redfish was evidently over, humpbacks were very abundant, and there were many Dolly Varden and cut-throat trout, with a few of the rainbow species. It is stated that on July 4, 1895, redfish were running in the stream, that many were seen on that date in the lake, and that the Indians were using their funnel-shaped traps in the stream below the barricade.

There is no available record of this stream, but it may be said to have a value of 10,000 redfish during the season.

SITKOH BAY, STREAM, AND LAKE.

At the eastern entrance to Peril Straits, on the northern side, between Point Craven and Point Hayes, a deep indentation makes to the northwest, which is known as Sitkoh Bay. Within the bay, and 4½ miles from Point Craven, on the southern side, is a stream carrying redfish, which was examined on August 5 by a party in charge of Ensign Miller. This stream is a lake outlet, is about 4 miles long with a width at the mouth of about 30 feet and a depth of 6 inches; temperature of water 57° F. It flows with a strong current, in a general northeasterly direction, through a wide valley, over a rocky bed having at intervals areas of sand and gravel. There are no strong rapids or falls, and tide water ascends about 700 yards within the mouth. There are two small tributaries which enter from the southeastward, one near the lake having a temperature of 50° F., and the other, about midway of its length, a temperature of 55° F. The remains of three barricades were seen, located respectively 100 yards, 500 yards, and 1,000 yards within the mouth, none of which, however, had any indication of recent use.

The lake lies in a general northeast and southwest direction, is about 2 miles long, and from one-fourth to one-half mile wide. It has an elevation of 190 feet; temperature 55° F. at time of visit. The surrounding country is heavily wooded and near the upper part of the stream the borders are level with large flats at different points around the lake. The beaches are usually of sand and gravel.

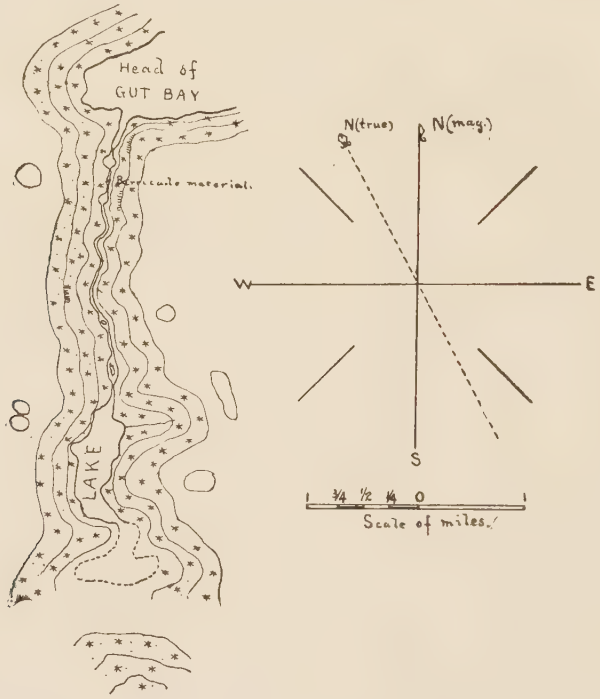
The only records of this stream available are from the books of the old Baranof Packing Company, as follows:

Year.	Species.	Date.	Number.
1890	Redfish	July 13–Aug. 4	4,902
1895	do	July 10–Aug. 8	4,260
1896	do	July 19–Aug. 11	15,794
1897	do	July 25	566
1890	Cohoes	Sept. 2–Sept. 17	2,354
1895	do	Sept. 5	1,252

GUT BAY, STREAM, AND LAKE.

On the eastern side of Baranof Island, 34 miles north from Cape Ommaney, a long, narrow bay makes to the westward for a distance of 4 miles. It opens on Chatham Strait and at its entrance is less than half a cable in width. At the head of the bay, on the southwest side, is the mouth of a small redfish stream, a lake outlet, which was examined by a party in charge of Ensign Kempff on August 6.

The stream flows from the lake in a general northerly direction for about 2 miles, in a channel marked by easy curves, over a bowlderous bottom, having in the lower reaches intervals of sand and gravel patches. At its mouth it broadens into a tidewater pool, largely bare at low water, and then widens to a narrow inlet which leads to Gut Bay. The stream is about 25 feet wide, 6 inches deep, and flows with a strong current, though there are no marked rapids or falls. The water is clear and



Sketch of Gut Bay, Lake, and Stream, Baranof Island, Alaska.

had a temperature of 51° F. There are two small wooded islands in the upper reaches, one near the head and the other one-half mile below. One-fourth mile above the tidewater pool referred to at the mouth, the stream widens into a pool 200 feet in diameter, with an average depth of 6 inches. Below this pool, on the western bank, were all the materials for a barricade, but the stream when visited was free from obstructions that would prevent the ascent of salmon. The wooded valley through which the stream flows is strewn with large bowlders. The mountains rise abruptly from the eastern side, while on the western side a wooded and bushy flat, about one-fourth mile in width, intervenes between the stream and the mountains.

The lake is elevated 100 feet above sea level, and, as far as could be examined, extends in a southerly direction for a distance of 1½ miles, with a width not exceeding one-half mile. The shores are in the main steep and rocky, though at the lower end there are generally mud beaches. A small feeder enters the lake from the eastward near the outlet, but it is probable that the main supply enters near the head, which point could not be reached. The temperature of the water was 55° F. No site suitable for a hatchery was noticed, but it is probable upon special examination that a location could be found. A large number of humpbacks were seen throughout the system.

The stream has never been regularly fished for cannery purposes, a seining crew simply calling from some cannery during the fishing season, and its value in redfish is therefore unknown, but it may be classed as one of the numerous small streams that may yield anywhere from 2,000 to 8,000 redfish a season. The only records available are the following, from the books of the old Baranof Packing Company:

Year.	Species.	Dates.	No.
1892	Redfish	June 14–June 26	1,673
	Cohoes	Aug. 27–Sept. 8	970
1893	Redfish	July 3–Aug. 19	2,766
	Cohoes	Aug. 30	293
1894	Redfish	July 30	630
1895	do	July 4–Aug. 2	6,716
1896	do	July 1–July 20	2,326

PRINCE WILLIAM SOUND.

FROM CROSS SOUND TO PRINCE WILLIAM SOUND.

After leaving Dundas Bay, in Cross Sound, there are no canneries until Prince William Sound is reached. There are, however, a number of streams, for the most part small (though the Alsek and several adjoining rivers are of considerable size), which carry commercial salmon. These streams, as a rule, empty directly into the sea and are inaccessible for commercial fisheries, though cannery experts have been in the field, and it is believed by next season fisheries in the Alsek region will be attempted.

Rounding Cape Spencer to the northward, about 4 miles, is an indentation which at its head is said by the Indians to receive the waters of a stream called Nook-hook-keen; this is the outlet to a system of three lakes, and is said to carry a few redfish. It is probably the stream which supplies a few redfish to the Dundas Bay cannery, and known to them as Cape Spencer.

About 3 miles to the northward of the stream just mentioned the Indians report a small stream with lake source, carrying a few redfish, and known as An-nock-seck.

Continuing to the northward, the Indians report a small redfish stream having a lake source midway between Icy Point and Harbor Point, and known as Ghow-nar-har, and about 6 miles above Harbor Point another outlet to a lake known as Hawg-heen, which is also said to carry a few redfish. These streams are for the most part inaccessible, and from all reports can hardly be classed as having any commercial importance, even if the fisheries could be properly conducted.

The next region to the northward carrying salmon is the Alsek which, with the streams between it and Yakutat, will be treated under one head.

ALSEK REGION.

About 60 miles southeast from Ocean Cape, which forms the southern entrance point to Yakutat Bay, the high mountain range of the Fairweather system recedes from the present coast line for a distance ranging from 6 to 14 miles, forming wooded plains, with gentle slopes ascending to the base of the mountain system. It is probable that the sea, during an earlier geological period, lapped the foot of the mountains and that the numerous glaciers, now visible on every hand, discharged directly into the ocean. The plain now fringing the mountain system is formed from the glacial débris, by moraine deposit and by stream detritus brought from the glaciers and thrown back by the sea. Through this action the coast line is undoubtedly extending seaward constantly, for the streams which drain the glaciers debouch directly upon the ocean and bring down a large amount of sediment to be deposited and cast up. The plains are traversed by numerous streams having their sources frequently in lakes and ponds, which receive the glacial drains, though there are some tributaries which drain the glaciers direct. These streams ramify in all directions, even to the extent of occasionally forming connecting passages with each other.

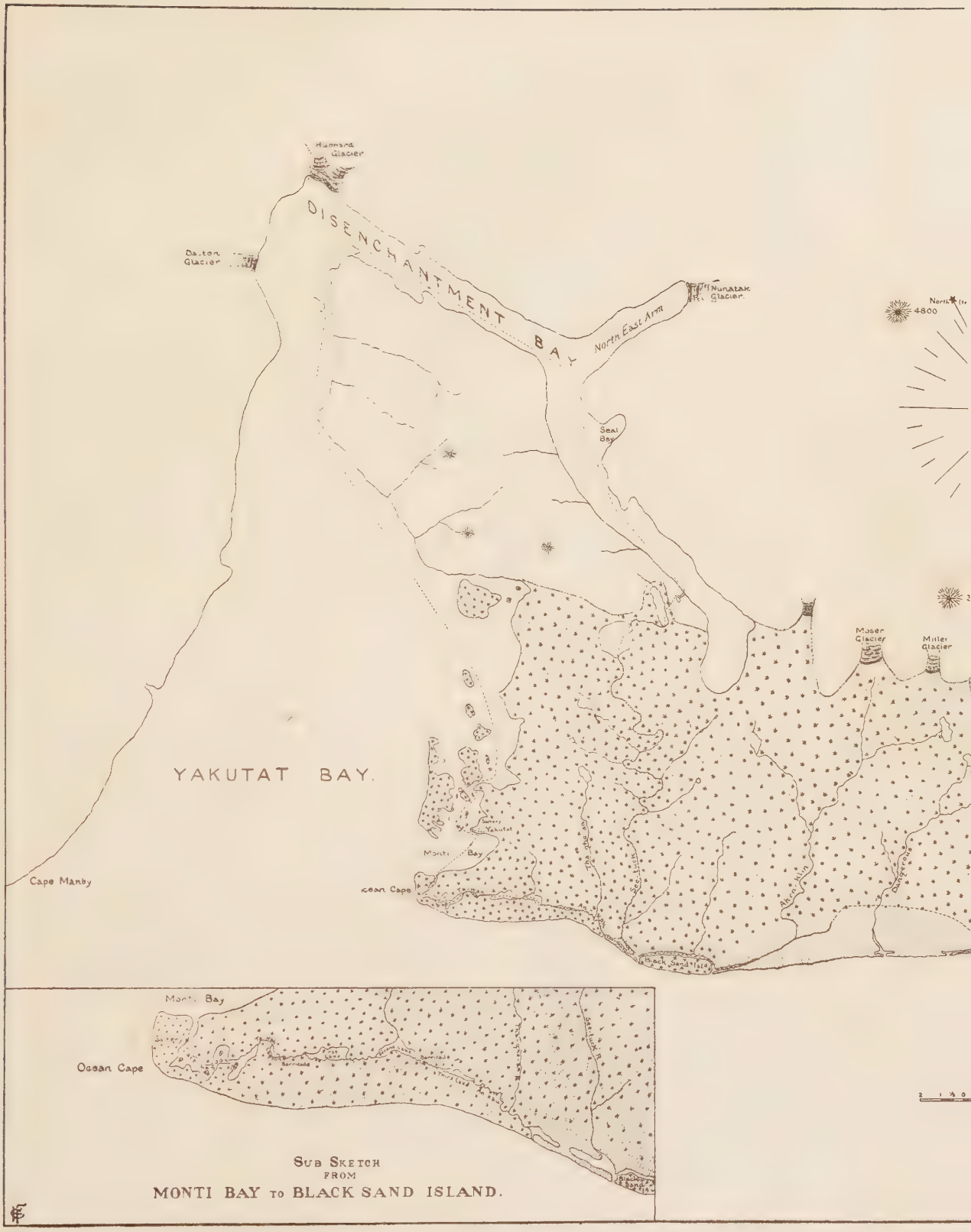
The Alsek, which is at the eastern end of these plains and debouches at Dry Bay, is independent, though it possibly receives some slight drainage water from the plains in its lower course before it forms the delta. This river drains the great ice fields north of the St. Elias and Fairweather ranges, one branch dipping around to the westward and tapping the St. Elias region, and another branch extending more to the northward into the Chilkat country. It breaks through the range back from Dry Bay, and, after cutting a large glacier lying near the northern end of the bay, forms its delta, which is really Dry Bay.

The Alsek and adjacent rivers to Yakutat all have runs of salmon, and in some all species are represented. According to the Indian reports and the statements of some fishermen who have visited the locality, salmon are very plentiful.

In order to have a better understanding of the region, Lieutenant Rodman and Mr. Chamberlain, with Indian guides and canoes, from July 1 to 6, made a trip from Yakutat Bay to the Alsek, and Ensign Miller, from the head of Disenchantment Bay, made a portage with Indian guides to the headwaters of the See-Tuck, and descending that stream returned to Yakutat through the chain of lakes and lagoons to Monti Bay. From the notes of these officers and from other sources the following is obtained:

It has been reported that by means of the lagoons, lakes, and intersecting streams an inside waterway exists from Yakutat Bay to Dry Bay, but such is not the case. It is true, however, that by waiting for the top of high water and making long detours, a canoe can be carried through by making several portages, but the route is impracticable for a boat of any size.

On the southern shore of Monti Bay, 2½ miles from the village of Yakutat, and a mile from Point Carrew, Cape Phipps Peninsula is penetrated by a shallow inlet, about 2½ miles in length, and on the charts misnamed Ankau Creek. From Monti Bay, it first tends to the southward, then to the eastward, and terminates in a T-shaped head, which lies in a general northeast-and-southwest direction. This inlet is very irregular in shape, and broken by islands and shoals, having narrow shallow channels between them. In entering, about 3 feet of water can be carried at half tide to the first turn to the eastward, when up to three-fourths tide there is a rapid.


Hubbard Glacier
DISENCHANTMENT BAY
North East Arm
Dalton Glacier
Nunatak Glacier
Seal Bay
Moser Glacier
Miller Glacier
YAKUTAT BAY.
Cape Manby
Ocean Cape
Monti Bay
Black Sand Island
Ocean Cape
Monti Bay
Black Sand Island
SUB SKETCH
FROM
MONTI BAY TO BLACK SAND ISLAND.

U. S. COMMISSION OF FISH AND FISHERIES
STEAMER ALBATROSS.

COMMANDER JEFF'N F. MOSER, U.S NAVY,
COMMANDING.

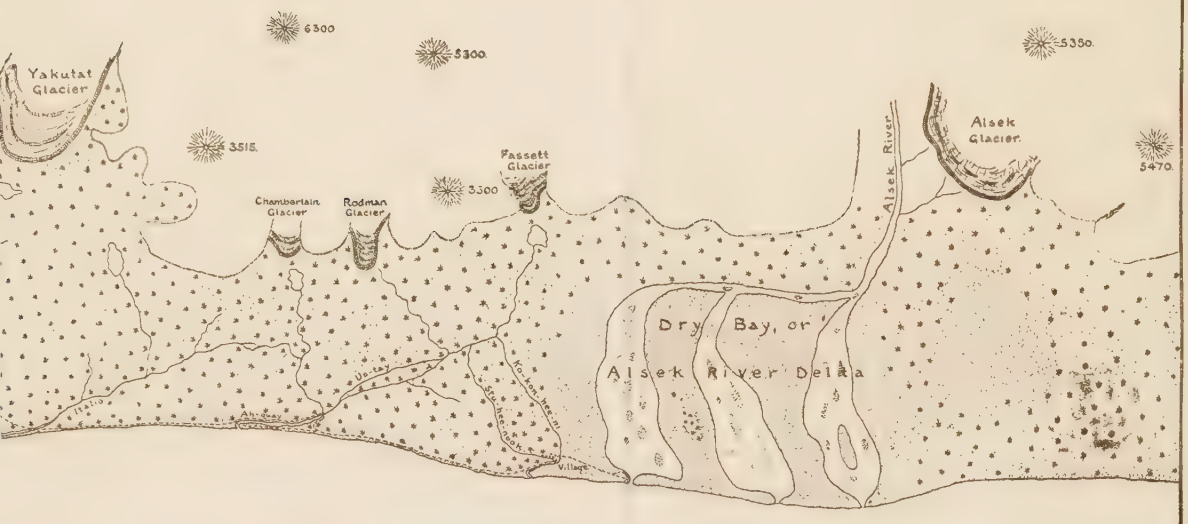
SKETCH OF THE

ALSEK RIVER DELTA
AND
ADJACENT STREAMS TO YAKUTAT.

JULY 1901.

AUTHORITIES:
(Base map - - U.S.C.& G.S. chart Nº 8500).
Alsek River and Adjacent Streams, Lieut Hugh Rodman, U. S. N.
See-tuck River - - - - - - - Ensign Cyrus R. Miller, U. S. N.

Approved:
Jeff F. Moser.
Commander, U.S.Navy,
Commanding.



Note - The channels of the Alsek River Delta are constantly changing. At Low Water 6 feet can generally be carried through the best channel.

Scale of Miles
0 4 6 8 10 12

At the head of the northeast arm the inlet receives the waters of a small stream called Ta-wah, which drains to the westward a system of shallow ponds and lakes, the latter having also an eastern drainage along the coast in the An-kau (On-cow) River.

Spring tides ascend the Ta-wah to a pond with which it is directly connected. This stream is less than half a mile in length and at low water is only about 6 feet wide and 3 inches deep. The rocks and bowlders have been removed from the bed and piled along the side, forming a shallow channel up which canoes are tracked at low water, but may be poled at high water. The bed is stony, with some sand and gravel, and the current sluggish. Temperature of the water July 1, 56° F.

The pond with which the Ta-wah is directly connected is a shallow pool 300 yards long, from a few inches to 2 feet deep, bottom rocky, with sand and gravel, over which there is a growth of grass and moss; a loaded canoe may be pulled and poled across. At the head of this pond are the remains of a slat barricade. The eastern end receives the waters of a small stream several hundred yards long, which connects the pond with what is known as the first lake. This connecting stream just permits a canoe to be hauled through, and is tortuous, with a sluggish current.

The first lake has its major axis east and west, and is about a mile long, with a width varying from several hundred yards at the western end to one-third of a mile at the eastern end; the depth varies from a few inches to 4 or 5 feet. The bottom is composed of sand and gravel, over which a few logs were noticed and much grass; a canoe may be pulled across. The first lake is connected with the second by a small stream or brook one-third to one-half mile in length, 6 feet wide, and 4 inches to 2 feet deep, which meanders through a low, flat country, and carries just sufficient water for a loaded canoe to be hauled through. Temperature of water, 54° F.

The second lake is slightly crescent-shaped, with the cusps to the southward, and lies in a general east-and-west direction. It is about 1¼ miles long, with a width varying from 100 yards to one-third of a mile, and has a depth of from 1 inch to 24 inches. The bottom is sand and gravel, with an abundance of grass and pond lilies growing over it. A canoe may be pulled across. The main feeder of this lake enters on the northern shore near the western end. It is said to rise back of Yakutat village and to be 3 or 4 miles long, 10 feet wide, and 8 inches deep, flowing with a sluggish current, through a winding channel, over a sand and gravel bottom. The water is clear and the stream bed is said to afford the main spawning-ground for this system. On July 6 it was full of redfish. This second lake forms the dividing line in this system, and drains both to the westward, as previously described, and to the eastward through the An-kau and connecting waters.

At the eastern end of the second lake is a small stream draining the system to the eastward. It flows in a general easterly direction through a narrow, tortuous channel for about a mile, when the so-called third lake is reached. A loaded canoe may be tracked through this connecting stream. The remains of a slat barricade are visible. This third lake consists of a series of small pools and swamps ramifying for a distance of 1½ to 2 miles in a general easterly direction, varying in width from 20 yards to one-third of a mile. It is full of small, low marshy islands and has a large growth of weeds, grass, and water plants. The bottom is muddy and there is a slight current. A loaded canoe may be poled through.

The eastern end of the third lake narrows into the An-kau River, which is a

fair-sized stream about 3 miles long, from 15 feet to 30 or 40 feet wide, and from 6 inches to 4 feet deep, flowing with a moderate current in a general SE. direction to the sea, into which it empties about 9 miles east from Ocean Cape. The channel is tortuous and the bottom is of sand and gravel. Tide water extends about 2 miles upstream, above a point where three houses and some drying frames are located on the southern bank and where the natives cure fish during the season.

About a mile above its mouth the An-kau receives a tributary, the Tha-ghe-an, about one-third the size of the main stream. It is said to drain a small lake 6 miles to the northward, which has redfish and coho spawning-grounds.

The mouth of the An-kau expands into a tide-water basin fully one-half mile in length at high water and formed by the action of the sea. At high water a canoe can be pulled from the mouth to a point near the third lake, and at any stage of the tide above the houses, beyond which point poling must be resorted to with some tracking.

Throughout this system from Monti Bay to the mouth of the An-kau many salmon were seen jumping. In the lower part of the An-kau redfish were very abundant on July 1, though the natives say there are more cohoes, which species they prefer for drying. With the spear the native is usually able to obtain all the fish he wants.

See-tuck River.—The next river to the eastward is the See-tuck, which has its origin in two connecting lakes, and receives in its course tributaries having lake sources. The upper lake of the main stream lies near the head of Disenchantment Bay and about 1 mile from it, opposite the fourth glacier and across the mountain range bordering the western side of the bay. It is 190 feet above the sea and lies in a basin whose walls rise from 500 to 2,000 feet. It is 1½ miles in length in a SE. direction, 200 yards to 700 yards wide, and had water of a greenish color, with a temperature of 45.5° F. on July 3. At the head is the main feeder, about 20 feet wide and 1 foot deep, flowing with a strong current a clay-colored water from the melting snow. The lake also receives the waters from numerous rivulets around the border. At the southern end is an outlet connecting it with the lower lake. This stream is 20 feet wide, 2 feet deep, and flows with a very swift current over a rocky and bowlderous bed having in places small areas of sand and gravel. The water has a milky tinge, and on July 3 had a temperature of 45° F. It has but one rapid, with a drop of about 4 feet. It retains its narrow bed, except at a few points, where it broadens out into shallows. After meandering westerly for about 4 miles the stream enters the lower or main lake.

This lake is circular, about 2 miles in diameter, and is 110 feet above the sea, and has clear water; temperature, July 3, 60° F. On the northern shore is a mountain about 2,500 feet high, and the eastern and western shores are covered with dead spruce and hemlock, caused, it is said, by a subsidence due to an earthquake in September, 1899. The outlet is on the southern side, and is the See-tuck River, which at the head is 50 feet wide, 2 feet deep, with a strong current. It flows through a winding channel to the sea, distant in a direct line about 13 miles. The water is clear and has a temperature of 60° to 62° F. The bottom at first is rocky and bowlderous, quickly changing to gravel and finally to sand and mud, as the sea is reached. The banks are low and covered with brush, giving ample evidence of a much larger stream during periods of freshets. About one-third its length from the lake the river receives from the westward the On-klat, a small tributary said to have a lake source. Two

more tributaries are received from the westward and two from the eastward, along the middle third of its length, draining ponds and marshes. It is said that salmon spawn in these tributaries and their sources. About 2 miles from the sea the Ku-na-yosh, about half the size of the See-tuck, joins the latter from the eastward. It is said to carry many redfish. There are several small islands in the See-tuck, but no natural or artificial obstructions to prevent the free ascent of fish.

Numerous king salmon and redfish and a few of the other species were seen in the river and a few redfish and one king salmon were seen jumping in the lakes.

A hatchery site might possibly be found in the locality, but inaccessibility would probably be a bar to its successful operation.

The mouth of the See-tuck is about 120 feet wide and 14 inches deep. It widens into a broad, sandy, tidal basin, full of bars, which connects with the sea by a channel having strong currents, in which it is said 6 feet can be carried at low water. This basin is connected, by a slough inside the coast line, with another tidal basin formed at the mouth of the Ahrn-klin, the next large stream to the eastward, and together they form an island called Black Sand Island. This slough is about 3 miles in length, 60 to 200 yards in width, and 12 to 15 inches deep at low water, with a tidal current which enters at either end. It forms a connecting canoe passage along the coast. At high water a canoe can be tracked from the An-kau basin into the See-tuck basin, but at any other time of tide it is quicker to make a portage from one-half to three-fourths mile across the flat from the An-kau basin to the See-tuck River proper, aiming to strike a point on the river where it leaves the tree line. No difficulty is experienced in passing from the See-tuck to the Ahrn-klin by the slough referred to.

The Ahrn-klin is said to receive the main body of water from three sources. First from a lake on the western foot of Yakutat Glacier, which is grayish in color, cold, and deep, and receives part of the drainage from the glacier. The outlet, after flowing to the southwest about 4 miles, is joined by a stream from the northward, of equal length, draining Moser Glacier; they flow together about 4 miles and form a junction with a stream flowing from the northwest, which is the outlet to a clear lake, about 3 miles southeast from Disenchantment Bay, which is said to be about 1 mile long, three-fourths mile wide, and to form a favorite spawning-ground.

There are several other small tributaries, some of which have clear water and drain ponds and small lakes, but none of importance.

The general course of the Ahrn-klin system is a little to the westward of south until within a mile of the coast, when it turns abruptly to the westward and follows the coast just inside a sand bar, where it forms a tidal basin. This basin is full of bars and strong currents, from which a channel, in which it is said 6 feet may be carried at low water, leads to the sea at the eastern end of Black Sand Island.

The Ahrn-klin is slightly larger than the See-tuck and is similar in its general characteristics, except that the water is glacial in color. Temperature, 51° F.

The mouths of the See-tuck and Ahrn-klin, as well as the connecting slough, were full of jumping salmon. It is said that king salmon, redfish, and cohoes ascend the Ahrn-klin, but that the See-tuck carries more redfish. The natives say they have taken 10,000 redfish from the See-tuck; if this is true, the stream must have a large fish value, as the natives have only very primitive appliances and take only sufficient for their wants. The fact is that the value of these streams is entirely unknown, as the natives obtain all the fish they want from the streams near their villages; and as

there are none of the latter between Dry Bay and Yakutat, the stream values for commercial purposes must yet be ascertained.

Dangerous River is the next to the eastward and is well named from the fact that it is full of quicksands, has numerous bars and islands, strong currents, and is ever changing its bed. It is considered a very treacherous stream and is feared by the natives. From an account given by the latter, it has its source in a lake about 1½ miles long by 1 mile wide, lying about 1½ miles from Yakutat Glacier. It flows with a strong current, in a general SSW. direction, carrying a large volume of water, and has a width in places of 150 yards and a depth ranging from a few inches to 4 feet. The water is very muddy and heavily charged with glacial detritus. Temperature, 47° F. It has several small feeders. The natives state that this river carries no redfish, but a few cohoes. It is doubted, however, if anything is known of its fishing value, as aside from the difficulty in operating a fishery there are no natives in the vicinity. It empties into a tidal basin which discharges into the sea in a manner similar to the other rivers. It can not be navigated above the basin except by a very small canoe, and even this is considered hazardous.

The canoe passage from the mouth of the Ahrn-klin is made by ascending that river and taking the first big slough on the eastern side to its head. Here a portage must be made across a small plain to Dangerous River, which can be done in from 45 minutes to 60 minutes, and thence by canoe across the river.

The *Italio River*, the next to the eastward, has its source in a lake, about 1½ miles long by 1 mile wide, which lies about 4 miles southeast from Yakutat Glacier. From the lake it flows in a southerly direction to a point where it is joined by a stream draining a pond, or small mud lake, lying more to the eastward. From this point of junction, which is about 7 miles from the mouth, it flows to the southwest; when near the coast it is deflected more to the westward and parallel to the ocean beach, from which it is separated by a low sandspit, about one-eighth of a mile wide, for a distance of 3 miles, when its channel leads into the sea. At the seaward end is a tidal basin, and it is probable that at high water with much surf on the outer beach the sea may break into the lower reach. It is said that the channel leading to the sea is working to the westward. There seems to be no reason why the river should not break through at any point along the low sandspit under conditions favorable for it. At the time visited the river 1½ miles above the seaward channel appeared more like a lagoon, one-eighth of a mile wide, 8 inches deep, with sandy bottom and feeble current, and was free from mud and plants. The volume of water is said to be about the same as in the See-tuck. It has the appearance of being a fine stream, clean and clear, and is said to carry about as many redfish as the See-tuck, many cohoes, and a few king salmon. The redfish are said to spawn in the lake and feeders lying toward Yakutat Glacier. Temperature of water, 50° F.

The canoe route from Dangerous River is to drop to the mouth of that stream and pass to the eastern end of the tidal basin; here a long portage must be made to the tidal basin of the Italio. The quickest and safest way is to cache the canoe at Dangerous River and pack across the sand plain to the Italio, skirting the tree line and fording the river; the depth is less than 2 feet.

The Ah-quay River is the next eastward and has its source in a lake, about 1¼ miles long by 1 mile wide, lying about 1 mile south from Chamberlain Glacier;

from the lake it flows with many bends and curves over a generally gravel bottom until within one mile of the coast line, where it is joined from the eastward by the Us-tay and is deflected around a high wooded point through 180°; it then follows the coast to the westward for 3¾ miles, when it breaks into the sea.

The Us-tay has its source in a lake about a mile in diameter, which lies under Fassett Glacier, and 6 miles below it gives off a branch called the Ko-kon-hee-ni (Stickleback), which flows SSE. The main stream continues to the southwest for a mile, when it gives off another branch called the Stu-hee-nook, which flows SSE. and unites with the first branch near the village near the western side of Dry Bay, and together they flow to the westward about a mile and empty into the sea. The combination of the three rivers forms an island with the village on the southeast side.

The Us-tay, after giving out the branches just mentioned, receives a tributary from the northwest which flows from the Rodman Glacier and immediately below it divides, flowing as two streams and uniting a short distance above its junction with the Ah-quay, thus forming an island about 4 miles in length.

All these streams are glacial. Below the junction of the Us-tay with the Ah-quay the stream is from 75 yards to one-fifth mile in width, from 4 inches to 4 feet in depth, and of a character similar to Dangerous River. The Ah-quay above the junction is about the size of the Italio. Its mouth, around which were many seals, narrows to 75 yards and is moving to the westward. The Ah-quay and the Us-tay are said to carry large numbers of king salmon, redfish, and cohoes, and the former has a run of eulachon in the early spring. In the lower Ah-quay gill nets could be used, and higher up seines, but navigation is hazardous on account of numerous bars and quicksands, which have but slight surface indications.

The Stu-hee-nook is a small stream about 15 yards wide, a few inches deep, and flows with a sluggish current, while the *Ko-kon-hee-ni* is probably three times as large. Both carry redfish and cohoes in large numbers, and at their junction, on July 4, several canoes were employed spearing redfish. This whole system, called the Ah-quay, is said to carry a very large number of king salmon, redfish, and cohoes.

The canoe route from the mouth of the Italio River is to ascend that river, keeping in the tributary that flows from the ENE. to the small mud lake. Here a hard portage through the timber to a small tributary of the Ah-quay is necessary; thence the route is down that stream to its junction with the Us-tay, up the latter to the Ko-kon-hee-ni, and down this stream to the village.

If, however, it is concluded to pack from Dangerous River, then, after crossing the Italio at the point previously described, take the outside beach to the Ah-quay, following the right bank of that river for about 3 miles from the mouth, or until the first wooded belt, a broad, treeless, sand plain, and then the second wooded belt are passed, where there is a low, grassy plain, and where the river can be forded when it is under normal conditions. Caution, however, must be used, as there is considerable quicksand, but by using a pole and sounding ahead a passage can be made. A canoe is usually kept on the eastern side of the Ah-quay, near its junction with the Us-tay, for ferrying. Having passed the Ah-quay, the sea beach affords an excellent highway, particularly at low water, and can be followed to the mouth of the Ko-kon-hee-ni, whence a well-defined trail leads to the village.

Dry Bay, which is the delta of the Alsek River, covers from 80 to 100 square miles, the river flowing into the sea by three separate channels. After passing the

glacier previously referred to, the main body of water is deflected to the westward after giving one branch to the southward. A few miles beyond another part breaks to the southward, while the remaining portion continues yet a few miles when it, too, turns to the southward and enters the sea. From the point of departure from the main stream the branches form very large basins which close in toward the sea and empty through narrow channels. These basins are filled with bars and small islands with ramifying channels, all changing from day to day, and even from hour to hour. The only permanent feature in the delta appears to be a large, rocky, wooded island between the western and middle basins, which, on range with the Alsek Glacier, leads close to the western mouth. On July 4, 1901, the western channel was the largest, about 400 yards across, and on June 8 had the best water—6 feet on the bar at mean low water. The middle channel, 5 miles distant, was about 200 yards wide, and the eastern channel, 3 miles beyond, was 350 yards wide. Neither the width, depth, nor position, can be depended upon, as a week later the best water may have been in one of the other channels. The natives state that the current usually flows out and that an anchorage may be made by small craft in from 8 to 9 feet inside the western bar.

The bed of the river above the glacier is rocky and bowlderous, with areas of sand and gravel. The current is very strong, but a good boat can be hauled and poled upstream a considerable distance. The water temperature July 4 was 54° F. The Alsek is highest in the spring and lowest in September. It is said that salmon ascend the Alsek for 50 miles and that there is a large, clear lake in the interior.

The natives fish the Alsek but little, as the smaller streams, which furnish them with all the fish they can use, are more accessible, but they all agree that king salmon, redfish, and cohoes, ascend the Alsek in countless thousands. The idea of abundance as expressed by a native, however, must be received with caution, as he usually has no idea of the great capacity of a large cannery.

In the Alsek the natives report the king salmon as commencing to run about the last of April, and with them are found a few redfish, which species, however, does not run strong until July 1; the cohoes follow during the early part of August.

In a cursory examination of this kind it is impossible to state anything definite in regard to hatchery sites. It is probable that upon thorough investigation such sites could be located, but much difficulty would be encountered in obtaining pure water, as all of these streams are more or less glacial in origin. Outside of these facts, however, is the question of accessibility. There are no villages or permanent habitations between Yakutat and Dry Bay, and the journey, even in summer, with a light two-man canoe, is not an easy one, and is accompanied by some risk.

The plain between Yakutat and the Alsek, and bordering the mountain system to the sea, is for the most part wooded with spruce, hemlock, alder, and cottonwood, with a smaller growth of willows and elder, accompanied by the usual berry bushes, devil club, etc. From Black Sand Island to the mouth of the Italio there is an extensive treeless sand plain reaching several miles back from the coast line. This plain is cut up by small, shallow, spreading streams, having little or no current, with some shallow ponds, and a portion of it has a scant growth of grass and weeds. In very dry weather sand storms occur, and it is said they are at times dangerous.

The coast seaward appears to have no outlying dangers.

Since the apparent decline of the salmon fisheries on the western coast of the United States attention has been called to Alaska, and the Alsek region has not escaped the eye of the canner. The locality has been visited during the past two years by several individuals with the idea of obtaining the salmon in the streams, but as yet no steps have been taken to even prospect the region. It is reported that cannery sites have been selected in Monti Bay with the idea of conveying the catch from the Alsek and adjacent streams to that point, while other sites have been selected in the vicinity of the Alsek. Either proposition presents conditions difficult to overcome, and some very wild schemes are spoken of—one to build a railway from Monti Bay to the Alsek; another to transport the fish by trolley, and another, and the only feasible plan, to build light-draft surf tugs to cross the different bars. There is no feasible inside water route nor can one be made and maintained at a sum which the fisheries would warrant.

It is believed, through the reports made by the Indians and from the number of fish seen jumping by those who have visited the section, that there are a great many salmon of all species in the Alsek and adjacent streams to Yakutat, but nothing is definitely known of the abundance. Yet it may be conceded that there are sufficient salmon in these streams to supply several large canneries. To catch them legally, to collect them at certain centers for transportation, and to transport them are propositions that will tax the resources of the canner to the utmost.

A cannery is generally located at a point accessible to the home transporting vessels in preference to a locality at the fisheries and inaccessible to the transports; so that Monti Bay would probably be the most feasible point for a cannery location.

All these streams have tidal basins, greater or less in extent, into which they discharge and from which a channel leads into the open sea, usually over a bar over which about 6 feet may be carried at low water. The gill-netter will find the waters here shallow and the channels obstructed by bars and quicksands; the trap-man will find that his piling will not stand, and the drag-seine man will find the banks giving away under his feet. To find better conditions the higher reaches will be resorted to. The weather in summer along the coast is usually good and the surf on the bars is not heavy, but as fishing for king salmon would commence the last of April or early in May gales may be expected that would interfere with transportation. In fact, even under fair conditions it would be a question whether many fish would reach the cannery in Monti Bay in good condition. Experience in the locality may solve many of the questions now presented, but at best the pack will be an expensive one.

The small steamer *Beaver* and a large naphtha launch belonging to the Western Fisheries Company, at Dundas Bay, both crossed the Alsek bar during June and carried a few king salmon to their cannery. The *Beaver* made one trip and the naphtha launch at least two. The last time the latter crossed she rolled over and filled, but was floated, with the loss of her upper works. This cannery expects next year to fish the Alsek, making a sea run from the cannery of from 90 to 100 miles.

YAKUTAT.

There do not appear to be any streams in Yakutat or Disenchantment Bay that carry salmon in sufficient quantities for cannery purposes, but the prospects of the Alsek and the adjacent streams have been an inducement for the location of several

salteries in Monti Bay each with a cannery as an objective if the fisheries should prove of sufficient value.

Saltery of F. A. Fredericks Company.—This company hails from Seattle, Wash., and during the fall and winter of 1900, in the schooner *Martha W. Tuft*, salted 1,285 barrels of herring in the vicinity of Yakutat. In the spring of 1901 this company built a large saltery on the northern side of the head on which the village of Yakutat is now located. The intention was to salt herring, and if salmon could be obtained to extend their operations to that species.

Saltery of See & Flenner.—Messrs. A. L. See and A. Flenner, at the time of our visit (July 3), had in course of construction a saltery on the western point of the entrance to An-kau Creek, about 2 miles from Yakutat post-office. One building, 20 feet by 40 feet, had been erected in a bight within the entrance to the creek, and another was in course of construction on the point, which was to be connected with the first by a tramway 1,700 feet long. It was the intention to salt herring, and salmon also if they could be obtained; for the latter, 2 salting tanks had been provided. No salting had been done at the date of our visit.

Cannery and railroad proposition, Yakutat Bay to Alsek River Delta.—In the fall of 1900 and spring of 1901 a gentleman from San Diego, Cal., prospected this region with a view of establishing a cannery. He visited the Alsek and adjacent streams, and concluded that there was an abundance of fish, but that it is impracticable to transport them by water if the cannery were located in Monti Bay; also, that it is impracticable to handle the cannery equipment and the pack over the Alsek Bar if the cannery were located in that vicinity.

At Yakutat it was reported that a party in Seattle was interested in and intended raising money for the purpose of building a railroad from Monti Bay to the Alsek, a distance of about 60 miles, to carry the fish from the Alsek district. At a location on the southern side of Monti Bay, in a bend about one-half mile from the mission, a wharf 300 feet long, to accommodate steamers, is to be built, and whenever the railroad is completed a cannery plant is to be erected. This is mentioned simply to indicate the wild schemes spoken of in Alaska. At the time of our visit all there was in the locality to give the project any credence was a small bunk-house and a wharf about 100 feet long built from the bank to the high-water mark.

South Alaska Packing Company.—During the season of 1900 a fisherman by the name of Flemming examined the stream conditions from Yakutat to the Alsek. Upon his report a Mr. Shaw went over the ground during the spring of 1901, on the part, it is said, of an organization called the South Alaska Packing Company. Mr. Shaw had returned south before our arrival, but it was reported in Yakutat that several sites for canneries had been located. Inquiry in San Francisco elicited the information that the company no longer existed.

PRINCE WILLIAM SOUND STREAMS.

The streams and fisheries of this district were referred to in my report of 1897, pages 137–139, and as there has been no material development or change, the general conditions need not be repeated here. At the time of our former visit we were unable to make an examination of the streams and lake systems on account of the lateness of the season, and therefore accepted this work as a part of the examination

to be conducted this year. The streams are similar to those of Southeast Alaska, but in proportion to the territory covered are far less prolific in choice commercial salmon. If all the streams in the sound proper, at least so far as known, were fished legally throughout the season, it is doubted if 100,000 redfish and 50,000 cohoes could be taken under average conditions. The humpbacks are more plentiful and, as far as our personal observation goes, they seemed quite abundant.

The time of runs in Copper River is early, and that in Prince William Sound corresponds with Southeast Alaska, so that when the redfish have stopped running in the first-named locality they commence running in the second, and the canneries then pick up a few redfish in connection with the humpbacks, which are packed as soon as fishing on Copper River ceases. Were it not for this difference in time of runs it is doubted if any redfish would be taken from the sound, particularly as the redfish streams are from 60 to 100 miles from the canneries.

All these streams have been barricaded, the evidences of which still exist, and it is possible that this practice is still resorted to during the fishing season.

The stream at Cheniga, which produces more redfish than the combined output of all the other streams, it is said, was tightly dammed for many years, and it is frequently referred to as an example by those who argue against the parent-stream and four-year theories.

CHENIGA STREAM AND LAKE.

In the western end of Prince William Sound, opposite Herring Bay, on Knight Island, a point projects from the mainland known as Point Nowell. Rounding this point to the northward is an indentation in two parts. The outer is a round bay, about 1½ miles in diameter, connected by a narrow passage with a tidal lagoon of irregular form, about 3 miles long, which receives at its head the waters of Cheniga stream, the most productive redfish stream in Prince William Sound. It is a lake outlet, and was examined by Ensign Hepburn on July 12.

The stream is about one-half mile long, 30 feet wide, 10 inches deep, and flows with a strong current over a stony bottom in a NE. direction, which is the line of bay and stream system. The water is clear and had a temperature of 55° F. The upper half of the stream is quite straight, and the lower half gently curving, and, as there is a fall of 110 feet from the lake to the mouth, its course is almost one continuous rapid, but there are no serious obstructions to the free ascent of fish.

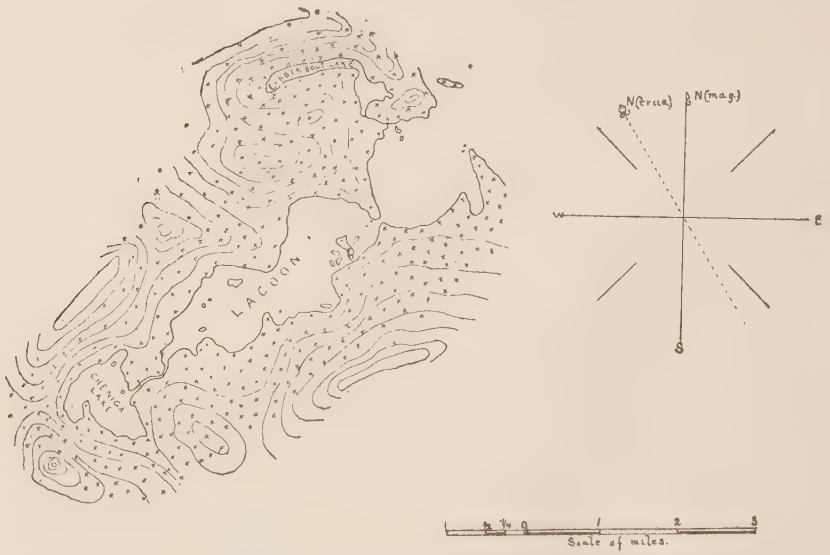
The mountains forming the valley through which the stream runs lie well back on each side with occasional projecting spurs through which the stream has cut its way so that the banks are alternately low and flat, and steep but not very high. The vegetation is that common to Southeast Alaska, although the forest trees are nearly all small spruce, with a heavy undergrowth of berry bushes, devil's club, and coarse grass. At the head of tide water, and ranging across the stream, are three triangular log cribs, substantially built and filled with rocks, and on the left bank is a pile of poles that may be used for the barricade. This stream was tightly barricaded for many years, and it is probable when the fishing gangs arrive that the stream is closed during the season. There is a log jam near the lake, but it forms no serious obstruction to the passage of fish.

The lake is an irregular, triangular-shaped body of water, about a mile in length on each side. The water is clear and the bottom, wherever it could be seen, is sandy,

The lake is walled in by high mountains, and from the general features it is likely that there is no other lake in the system, nor any feeders that may be used for spawning, as the shores descend very abruptly. Temperature of water, 55° F.; elevation, 110 feet. A few small fish were seen in the lake and redfish were seen jumping around the mouth of the stream. The streams in Prince William Sound give such poor returns that they are only resorted to by the canneries when the catch at Copper River runs short or the season there is over. No accurate values therefore can be given.

The Pacific Steam Whaling Company's cannery keeps no record of catches by streams and has rarely fished in Cheniga. It is believed if Cheniga were fished legally throughout the season it might yield, under average conditions, 40,000 redfish. The catch for 1896 was an exceptional one. The following data are from the books of the Alaska Packers' Association cannery:

Year.	Dates.	No. of redfish.
1896	July 4–Aug. 24	77,866
1897	July 1–Aug. 10	23,363
1898	July 5–31	2,893
1899	July 5–Aug. 2	7,396
1900	July 11–27	18,587



Sketch of Rubber Boot and Cheniga Lakes, Prince William Sound, Alaska.

RUBBER BOOT STREAM AND LAKE.

This stream, a lake outlet, discharges into the northwestern side of the outer bay described under Cheniga, and was examined July 12 by a party in charge of Ensign Hepburn. It is a small stream, about 250 yards long in a direct line, 12 feet wide and 6 inches deep, and flows with a very strong current over a rocky bottom on a fairly straight SE. course. The fall from the lake is about 50 feet and the stream is one continuous rapid, which salmon can probably ascend, but with some difficulty. The banks are heavily wooded with a scrub growth, bordered near the stream by a grassy

HUBBARD GLACIER, YAKUTAT BAY AND VICINITY, ALASKA.

FOURTH LAKE, JACK POT SYSTEM, PRINCE WILLIAM SOUND, ALASKA.

flat. The water is clear, slightly tinged, and has a temperature of 58° F. Tide water extends about 20 yards within the mouth to a point where the remains of a barricade, consisting of the usual felled trees and split poles, were found.

The lake is an irregular-shaped body of water, enlarging near the source of the outlet to about one-half mile in diameter, from which a curving arm, walled in by high mountains, extends over a mile to the westward. The bottom is muddy and stony and the banks are steep. There is a small wooded islet near the center of the eastern part of the lake. For want of facilities the lake could not be examined in all parts, but a number of very small feeders were noticed flowing in on the western side; from the configuration of the country it is not believed there is any feeder of considerable size or other lake connection. No fish were seen in the stream or lake, but a few redfish were jumping around the mouth of the outlet. This stream, if regularly fished, might yield under average conditions from 3,000 to 5,000 redfish during a season. The following are the only stream records available:

Year.	Dates.	No. of redfish.
1896	July 24	1,759
1897	July 15–Aug. 10	3,625
1898	July 5–July 31	2,338
1899	July 5–July 18	881
1900	July 11	142

JACK-POT STREAM AND LAKE.

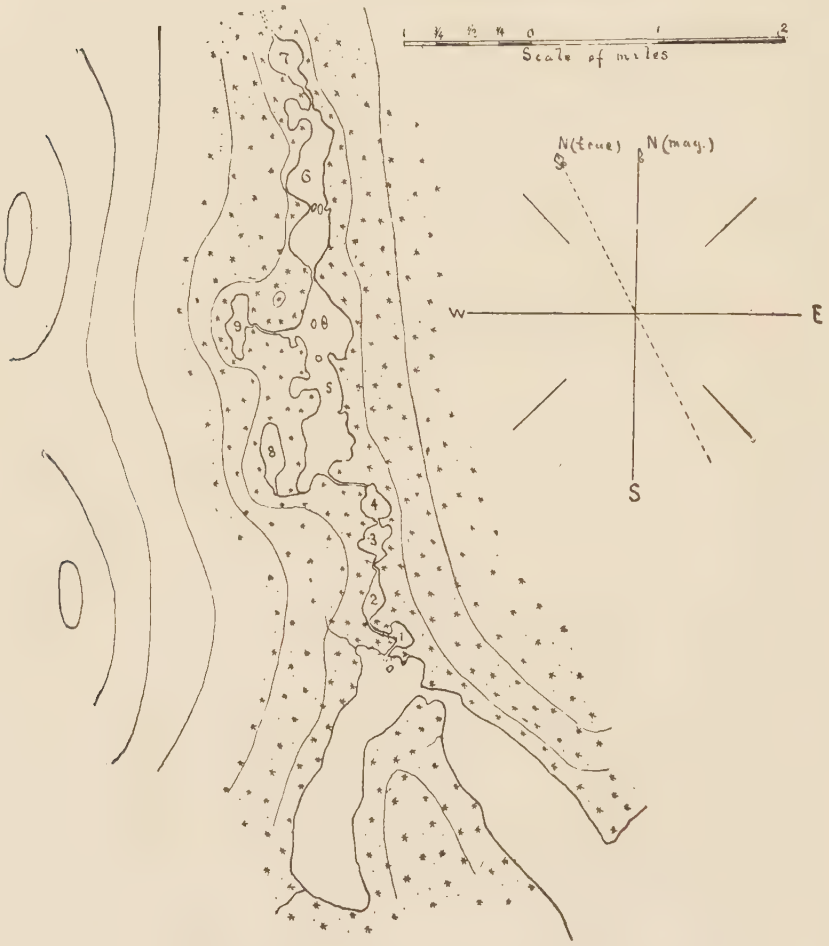
On the mainland, in the southwest end of Prince William Sound, opposite the lower end of Cheniga Island, is a deep bay making to the northwest for several miles, and then, by a narrow passage, connecting with a large bay extending some distance to the southward. Beyond the connecting passage, on the northern shore, is the outlet to a system of lakes and ponds, carrying a few redfish; this was examined by a party in charge of Ensign Miller on July 15. The series consists of 9 lakes, lying in a narrow valley in a general north-and-south direction, 7 connected on line, and 2 sublakes connected with No. 5. Nos. 5 and 6 are quite large; the rest are small. Very little current was noticed in the lakes, but the connecting streams have rapids, though the fall is not great, as No. 7 has an elevation of only 60 feet. Temperature of No. 7, 57° F. No. 9 is elevated about 50 feet above No. 5.

Lake No. 1 is small and is reached by tide water. It is about 200 yards from the bay, and at high water 4 or 5 feet can be carried in, while at low water there is a fall of from 10 to 12 feet. The outlet is about 50 feet wide, 18 inches deep, and had a temperature of 46° F. Fishing operations are carried on in Lake No. 1, and in the passage connecting No. 1 with No. 2 the remains of a barricade were found.

The system is bordered by hills, about 300 feet high, behind which lie high mountains. Occasional flats border the hills. The banks are rocky where observed, and the bottom is of the same nature, though doubtless there are areas of sand and gravel. The vegetation is of the usual Southeast Alaskan type. There are no obstructions to prevent the ascent of fish. Humpbacks were seen spawning in the middle lakes. No feeders of any importance were noticed, though it is probable that there is a large stream at the head of No. 7. The system was visited after prolonged rains, and it was with the greatest difficulty that the party was able to traverse the western side, and it was impossible to cross to the other side.

It is estimated that by fishing throughout the season 7,000 redfish might be obtained under average conditions. The following are the only data available:

Year.	Dates.	No. of redfish.
1896	July 22 and 24	3,332
1899	July 11 and 15	307
1900	July 11	142



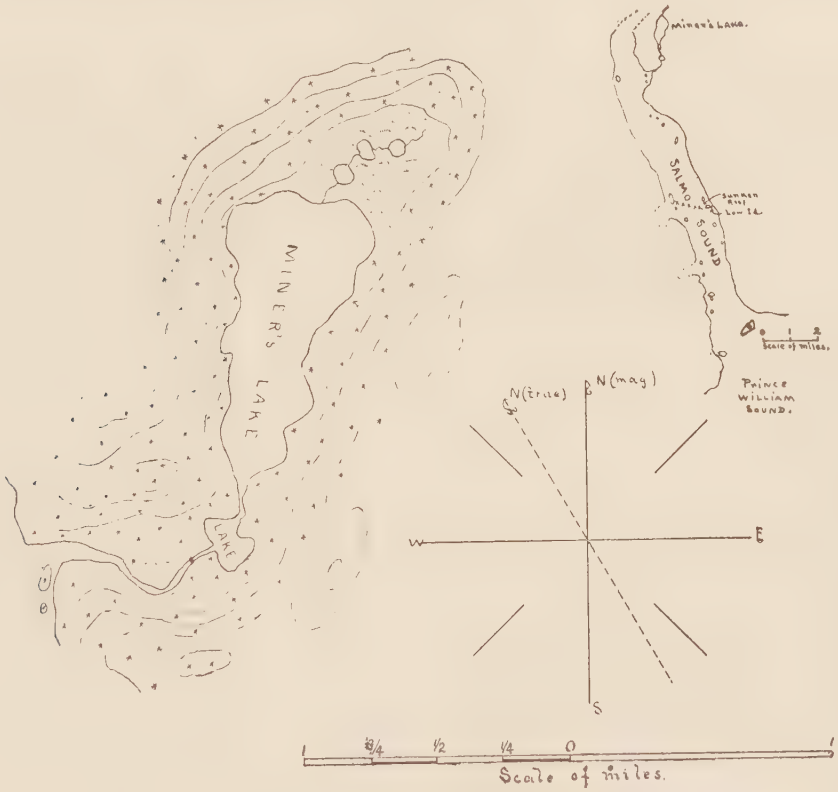
Sketch of Jack-Pot Lake and Stream System.

MINERS STREAM AND LAKE.

On the northern side of Prince William Sound, west from Glacier Island, is a wide, deep inlet known as Salmo Sound. About 10 miles from the entrance to this sound, on the eastern side, is an indentation marked on the southern side by a steep, bare hill of brownish rock behind two wooded islands, which receives the waters of a stream carrying a few redfish. This stream was examined by a party in charge of Ensign Kempff on July 16, and is the outlet to two lakes lying in a north-and-south direction in a broadening valley.

The upper lake has an elevation of 25 feet, and is about 1½ miles long, with an extreme width of ½ mile. The shores, except at the northern and southern ends, are steep and rocky, and bordered by hills from 300 to 400 feet high, back of which the land rises to the higher snow-covered mountains. At the northern end is a series of ponds, lying in the lowlands and connected with each other and the lake. The water is glacial, and had a temperature of 44° F., which was that of the whole system.

The upper lake is connected with the lower one at the southern end by a stream, which is 75 yards long, 35 feet wide, about 9 inches deep, and flows with a strong current over a bowlderous bed in a general south direction. The lower lake, about



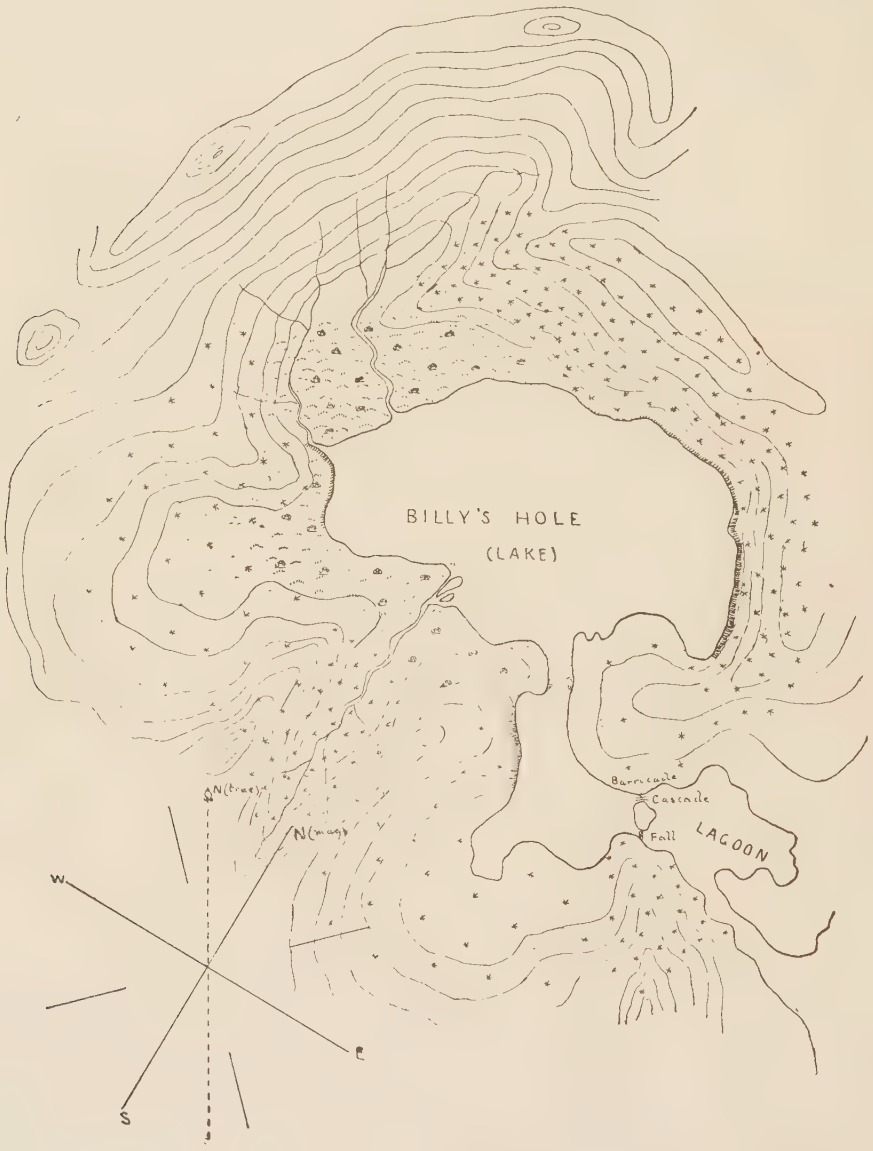
Sketch of Miners Stream and Lakes.

one-fourth mile in diameter, is shallow, and surrounded by wooded and grassy flats. The beaches are of mud and rock; the water is glacial. This lower lake empties into the inlet through a stream one-fourth mile long, 50 feet wide, and about 6 inches deep, flowing in a southwest direction with a very strong current over a bowlderous bed. There are two rapids a short distance below the lake. A few redfish were seen jumping near the mouth of the stream, but none were seen in the stream or lakes. The spawning-beds are in the streams and ponds at the head of the upper lake.

There is no stream record available. It is estimated by those acquainted with the locality that it should yield, under average conditions, 10,000 redfish by fishing throughout the season.

BILLYS HOLE LAKE AND OUTLET.

On the northern shore of Prince William Sound, northwest from Glacier Island, is a large bay. It is the second indentation west from Point Fremantle, the western entrance point to Port Valdes and about 8 miles from it. At the head of the bay a



Sketch of Billy's Hole and Outlet (Lake), Prince William Sound, Alaska.

narrow strait runs about due west for 400 yards and connects with a small salt-water lagoon which receives the discharge from a lake and carries redfish. It was examined July 17 by Ensign Hepburn.

There is no stream of well-defined limits which forms the outlet, the waters of the lake falling directly into the western end of the lagoon with a drop of about 6 feet at high water. In the middle of the outlet, surmounting the brink of the fall, is an island that divides the discharge into two equal parts. That part south of the island has a sheer fall and is not passable to salmon. The western portion is a cascade up which salmon can run when it is not barricaded. Some logs, evidently the remains of a barricade, were found across the top of the cascade and some wire netting lay on the bank near by, but when visited there was no obstruction to the passage of fish. The lake is in two parts, or it may be said there are two lakes connected by a short broad stream. The smaller and lower lake is irregular in form, one-fourth of a mile in length by half that width, with gently sloping banks except on the western shore, where there are precipitous cliffs. In the center it appears rather deep. The bottom consists principally of smooth, sloping rocks with sandy and gravelly spaces between. The larger lake, lying just north of the smaller, extends in a WSW. and ESE. (mag.) direction for about three-fourths mile, with a greatest breadth of one-half mile. The eastern and about half of the northern shores are steep and densely wooded with a tangled undergrowth. Around the western end there are flats extending from one-eighth to one-half mile back to the foot of the mountains and hills forming the lake basin. These flats are covered with grass and bushes and dense thickets of scrub alder. Two feeders enter the lake on the northwestern side. They both flow through a large valley extending almost north and south (mag.) and are formed from the melting snows. The stream flowing down the eastern side of the valley is the larger. It flows over a stony bed with a strong current, has a width of 15 feet and an average depth of 5 inches. It had a temperature of 46° F. The other stream in this valley is much smaller. It has a width of from 3 to 20 feet, depth from 2 inches to 1 foot, and a moderate current. A third, formed largely by draining the melting snows, enters the lake on the southern shore. It flows through a deep and very narrow valley extending to the southward, has an average breadth of 20 feet, depth 4 inches, and a strong current; temperature, 43° F. The lake water had a temperature of 50° F. and is very clear. The bottom appears to be mainly of rock, with some sand and mud patches. The bones of fish were seen scattered all along the shores of the lake, but no live fish were seen, except a few red salmon jumping in the lagoon.

A hatchery might be located at the mouth of the feeder on the southern shore, though the question of a sufficient supply of water during a dry season might need further investigation.

There is no record of this stream available. It is usually fished by the cannery located at Orca. It is believed by those competent to judge that the stream, under average conditions, should yield 20,000 redfish during the run.

PRINCE WILLIAM SOUND CANNERIES.

The two canneries operating in this locality—the one by the Alaska Packers Association (Pacific Packing Company) at Odiak and the other by the Pacific Steam Whaling Company at Orca—are each in about the same working condition as noted in former reports, to which reference is made. In the Alaska Packers Association cannery fish-cleaning machines have been introduced, but it is understood they are still in the experimental stage and require some changes before they can be

pronounced a success. One set of can-makers was in operation in this cannery this year, which averaged over 40,000 cans per diem. All the cans were made on the ground except 10,000 cases which were carried from San Francisco; 100-pound domestic plate was used throughout. The Chinese and fishermen contracted on practically the same terms as given in my previous reports.

Halibut and cod are common around the canneries and trout are abundant in the streams of Prince William Sound. Early in the spring a few steelheads are taken in the delta of the Copper River.

The following averages per case of fish taken in the Copper River delta during different years may be of interest as indicating the possible variations from year to year: King salmon, $3\frac{7}{8}$, $4\frac{1}{8}$, 4, $4\frac{1}{8}$; redfish, $9\frac{3}{4}$, $11\frac{1}{7}$, $10\frac{1}{2}$, $11\frac{1}{2}$, $11\frac{2}{3}$.

COPPER RIVER DELTA.

The conditions in this locality were fully described in my report for 1897, pages 129–139, and reference here will only be made to changes and additional information noted. The United States Coast and Geodetic Survey has extended its work over the delta as far as Cottonwood Point, and the location of sloughs with their distance from the canneries can now be indicated with accuracy. The mining excitement throughout this section has caused quite an influx of people, and communication is therefore much better and more reliable.

The cannery of the Peninsula Trading and Fishing Company at Coquenhena, referred to in my former reports, has been dismantled and the available machinery utilized in the Pacific Steam Whaling Company's cannery at Kenai, Cook Inlet.

The fishing localities in the delta are unchanged, except that the Chilkat River east of the delta is now more vigorously fished. Cannery steamers capable of going to sea carry the fish from the mouth of the river to the delta, and transfer them to stern-wheel steamers, which carry them to the canneries.

The value of the Chilkat River is unknown, but the following data, from the books of the Alaska Packers Association, may be of interest:

Year.	Dates.	Redfish.
1896	June 27 to July 15	23,980
1897	June 15 to June 29	39,269
1898	June 20 to June 29	39,383
1899	June 16 to July 4	27,072
1900	June 19 to July 6	106,167

U. S. Commission of Fish and Fisheries

Geo. M. Bowers, Commissioner.

SALMON INVESTIGATIONS

COAST OF ALASKA

DIXON ENTRANCE TO HEAD OF LYNN CANAL

SHOWING LOCATIONS OF

SALMON CANNERIES AND SALTERIES

AND THE

PRINCIPAL SALMON STREAMS

By Lieut. Comdr. Jeffn F. Moser, U.S.N.,

Commanding U.S.F.C. Str. Albatross.

1900

Scale 600 000

Base map: U.S. Coast and Geodetic Survey chart No. 8050.

● CANNERIES OPERATED, 1900.

1. Chilkoot Packing Co.
2. Pyramid Harbor Packing Co. (A. P. A.)
3. Western Fishing Co.
4. Taku Packing Co
5. Taku Fishing Co.
6. Icy Strait Packing Co.
7. Royer-Warnock Packing Co.
8. Glacier Packing Co. (A. P. A.)
9. Thlinket Packing Co.
10. Boston Fishing & Trading Co.
11. Alaska Salmon Packing & Fur Co. (A. P. A.)
12. Fidalgo Island Canning Co.
13. Metlakahtla Industrial Co.
14. Quadra Packing Co.
15. Pacific Steam Whaling Co.
16. North Pacific Trading & Packing Co.

◒ CANNERIES IN RESERVE, 1900.

21. Chilkat Canning Co. (A. P. A.)
22. Icy Strait Packing Co. Buildings erected.

⊕ CANNERIES DEFUNCT.

30. Northwest Trading Co.	Absorbed.	36. Baranoff Packing Co.	Abandoned.
31. Chilkat Packing Co.	Burnt.	37. Astoria & Alaska Packing Co.	Burnt.
32. Bartlett Bay Packing Co.	Dismantled.	38. Aberdeen Packing Co.	Sold and moved.
33. Astoria & Alaska Packing Co.	Moved.	39. Cape Lees Packing Co.	Dismantled.
34. Cutting Packing Co.	Abandoned.	40. Tongass Packing Co.	Burnt.
35. Baranoff Packing Co.	Moved.	41. Cape Fox Packing Co.	Sold and moved.

■ SALTERIES OPERATED, 1900.

50. Icy Strait Packing Co.
51. Perry Hinkle.
52. Perry Hinkle.
53. Icy Strait Packing Co.
54. Perry Hinkle.
55. Perry Hinkle.
56. Alaska Oil & Guano Co.
57. Great Northern Fish Co.
58. Jack Mantle.
59. Jack Mantle.
60. Zip Moon.
61. Finn & Young.
62. Icy Strait Packing Co.
63. Fred Brockman.
64. North Pacific & Norway Packing Co.
65. Icy Strait Packing Co., hulk "Blanche."
66. John Frey.
67. Tom McCauley.
68. Great Northern Fish Co.
69. Robert Bell.
70. John E. Rice.
71. Great Northern Fish Co.
72. Alex. Miller.
73. Z. Doty.
74. Craig Miller.
75. Banter & West.
76. Alaska Packers' Association.

▪ SALTERIES IN RESERVE, 1900.

77. Miller & Co.
78. Pacific Steam Whaling Co.
79. D. Blaauw.
80. James Turk.

⊞ SALTERIES DEFUNCT.

81. Morrissey.	Abandoned.	86. Indians.	Abandoned.
82. Tom McCauley.	Abandoned.	87. Martin & McKinnen (Clark & Martin.)	Abandoned.
83. Tom McCauley.	Abandoned.	88. Clark & Martin.	Abandoned.
84. Tom McCauley.	Abandoned.	89. Miller & Co.	Abandoned.
85. Robert Bell.	Moved.	90. Alaska Packers' Association.	Moved.

HATCHERIES, 1900.

▲ 95. North Pacific Trading & Packing Co.	Operated.
▲ 96. Pacific Steam Whaling Co.	Operated.
▲ 97. Capt. J. C. Callbreath's.	In reserve.
▲ 98. Baranoff Packing Co.'s.	Abandoned.
▲ 99. Capt. John C. Callbreath's.	Abandoned.

Statue Miles

Nautical Miles

U. S. Commission of Fish and Fisheries

Geo. M. Bowers, Commissioner.

SALMON INVESTIGATIONS
COAST OF ALASKA
FROM CAPE SUCKLING TO UNIMAK PASS
SHOWING LOCATIONS OF

SALMON CANNERIES AND SALTERIES
AND THE

PRINCIPAL SALMON STREAMS

By Lieut. Com'dr Jeff'n F. Moser, U.S.N.,

Commanding U.S.F.C. Str. Albatross.

1900

Scale 1:200,000

Base maps:

U.S. Coast and Geodetic Survey charts Nos. 8500 & 8800,

● **CANNERIES OPERATED, 1900.**

1. Alaska Packing Co. (A. P. A.)
2. Bristol Bay Canning Co. (A. P. A.)
3. Arctic Packing Co. (A. P. A.)
4. Pacific Steam Whaling Co
5. Alaska Fishermen's Packing Co.
6. Point Roberts Packing Co. (A. P. A.)
7. Kvichak Packing Co. (A. P. A.)
8. Naknek Packing Co.
9. Arctic Packing Co. (A. P. A)
10. Egegak Packing Co. (A. P. A.)
11. Ugashik Fishing Station (A. P. A.)
12. Bristol Packing Co
13. Chignik Bay Co. (A. P. A.)
14. Hume Bros. & Hume
15. Pacific Steam Whaling Co.
16. Arctic Packing Co. (A. P. A)
17. Alaska Improvement Co. (A. P. A.)
18. Karluk Packing Co (A. P. A.)
19. Hume Bros. & Hume.
20. Pacific Steam Whaling Co.
21. Ugamuk Fishing Station. (A. P. A.)
22. Arctic Fishing Co. (A. P. A.)
23. Pacific Steam Whaling Co.
24. Alaska Salmon Association.
25. Pacific Packing Co. (A. P. A.)
26. Pacific Steam Whaling Co.

◒ **CANNERIES IN RESERVE, 1900.**

31. Nushagak Canning Co. (A. P. A.)
32. North Alaska Salmon Association. (New.)
33. Chignik Bay Packing Co. (A. P. A.)
34. Kodiak Packing Co. (A. P. A.)
35. Hume Canning & Trading Co. (A. P. A.)
36. Hume-Aleutian Packing Co. (A. P. A.)
37. Kodiak Packing Co. (A. P. A.)
38. Northern Packing Co. (A. P. A.)

■ **SALTERIES OPERATED, 1900.**

61. C. F. Whitney & Co.
62. Eagle Harbor Packing Co.

⊕ **DEFUNCT CANNERIES.**

41	Bering Sea Packing Co	Moved
42	Bering Sea Packing Co	Abandoned
43	Thin Point Packing Co	Abandoned
44	Central Alaska Co	Abandoned
45	Western Alaska Packing Co	Abandoned
46	Shumagin Packing Co	Consolidated.
47	Arctic Packing Co.	Moved
48	Aleutian Islands Fishing and Mining Co	Consolidated
49.	Hume Packing Co	Consolidated
50.	Arctic Packing Co	Dismantled
51.	Royal Packing Co.	Dismantled
52.	Russian-American Packing Co	Abandoned
53.	Alaska Packing Co	Absorbed
54.	George W. Hume	Dismantled
55.	Pacific Steam Whaling Co	Moved
56.	Peninsula Trading & Fishing Company	Abandoned
57	Central Alaska Co	Moved
58.	Peninsula Trading & Fishing Company	Moved.

⊞ **DEFUNCT SALTERIES.**

71.	Togiak Fishing Station (A. P. A.)	Abandoned
72.	Bristol Bay Canning Co	Moved
73	Bristol Bay Canning Co	Sold and moved.
74.	Prosper Fishing & Trading Co	Absorbed
75.	Naknek Packing Co	Abandoned
76.	L. A. Pedersen	Absorbed
77.	Arctic Packing Co.	Absorbed
78.	Egegak Fishing Station (A. P. A.)	Abandoned.
79.	C. A Johnson	Absorbed.
80	Charles Nelson.	Abandoned.
81.	Alaska Packers' Association	Abandoned
82.	C. A. Johnson	Absorbed.
83.	Alaska Packers' Association	Abandoned
84.	Alaska Coast Fishing Co	Abandoned.
85.	Oliver Smith (A. P. A.)	Abandoned
86.	C. D. Ladd.	Absorbed.

HATCHERIES, 1900.

▲ 91. Alaska Packers' Association. Operated.

△ 96. Karluk River Fisheries Association. Abandoned.

NOTE:

This section of the map represents the western continuation of the upper section. The Scale in both sections is identical

Statute Miles

Nautical Miles

MORRIS PETERS CO. PHOTO-LITHO. WASH. D.C.

NOTES

ON

A SPECIES OF BARNACLE (DICHELASPIS) PARASITIC ON THE GILLS OF EDIBLE CRABS.

BY

ROBERT E. COKER.

NOTES ON A SPECIES OF BARNACLE (DICHELASPIS) PARASITIC ON THE GILLS OF EDIBLE CRABS.

By ROBERT E. COKER.

In the summer of 1900 Prof. H. V. Wilson, at that time director of the Beaufort Laboratory, suggested that, in view of the economic importance of the edible crabs, a fuller knowledge of the life histories of the ectoparasites of these forms was desirable. The following notes on one of the most interesting of such parasites are the outcome of an investigation carried on during parts of that and the following summer.

It is a pleasure to express my thanks to Professor Wilson for many helpful suggestions.

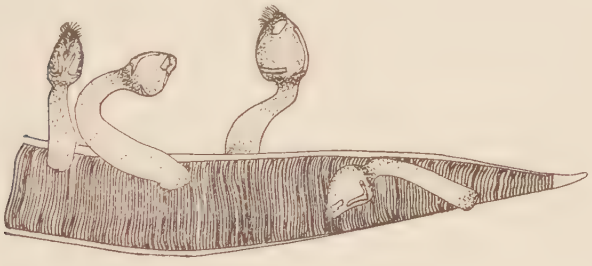


FIG. 1.—*Dichelaspis mulleri* attached to a gill of *Callinectes sapidus*. × 2.

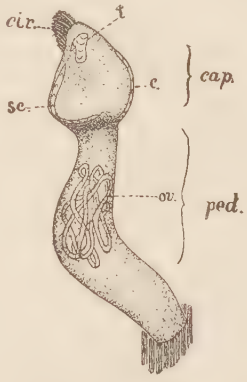


FIG. 2.—Single specimen of same. × 4.

OCCURRENCE AND HABIT OF ADULT.

A large number of the common edible crabs, or blue crabs (*Callinectes sapidus* [Ordway] Rathbun), of Beaufort, N. C., are found to be infested with a small lepadide barnacle, ectoparasitic on the gills (fig. 1). This form was first observed at Beaufort by Mr. T. G. Pearson. To ascertain somewhat definitely the proportion of crabs containing this parasite, record was made of 180 mature crabs examined during August and the first half of September, and barnacles were found in 128, or in 71 per cent. These crabs were taken just as they were brought into the laboratory, no selection being made except that soft crabs and evidently young crabs were disregarded. The barnacles were much more abundant later than earlier in the summer.

The sexes were found to be unequally burdened; the percentage for males infested was only 56, while for females it reached 89 per cent. It was also easily seen that the average number of barnacles in infested females was considerably above the corresponding average for males. A possible explanation of this difference is that

females when with eggs must be much less vigorous in their movements, because of the burden, but especially because of the necessity of having some care for the eggs. The consequently slower respiratory current would then afford better opportunity for barnacles in the free-swimming cypris stage to attach, as they are by chance sucked in and driven through the branchial chamber, or, if the cypris seeks out its host, the less active crabs will, again, be the easiest to find and to obtain attachment in.

The females also bore more of the *Balanus* barnacles on their shells; and it was further found that about four-fifths of those crabs on which the *Balanus* was seen would also contain *Dichelaspis*. It was rare to find a female crab with *Balanus* that had not also *Dichelaspis*. This fact is quite useful to one who is in search of the latter; promising crabs can be selected at a glance, even before capture. After ascertaining the above percentages, the collectors were asked to bring in only such crabs as carried *Balanus* barnacles.

It is to be presumed that these gill parasites are thrown off with the cuticle of the gill in the molt of the crab, and that the frequent molts of young crabs would prevent the barnacles on their gills from becoming conspicuous either in size or in numbers. It would then be expected, as indeed it is observed, that this *Dichelaspis* is not found in young or in soft crabs.

While one usually finds in an infested individual from two or three to eight or ten *Dichelaspis*, the number varies from one to as many as can be crowded into the branchial chambers—500 to 1,000, or perhaps more. In one instance observed the gill chambers had been filled to overflowing, and one or two barnacles were found attached without to a maxilliped.

This species of *Dichelaspis* is not peculiar to *Callinectes* as a host; both the edible stone crab (*Menippe mercenaria* Stimson) and the spider crab (*Libinia canaliculata* Say) contain it, but with less frequency. It is probably present in other large crustacea, lobsters as well as crabs, of other regions of the coast.

No organic connection between the barnacle and its host is found; and, while histological study of the parasite has not been made, no signs of degeneration are noted, except as to the extent of the calcified area of the valves of the capitulum; as will be seen later, too, the mouth parts are well developed. The barnacle is, therefore, to be regarded as a space parasite, which has become adapted to this habitat because of the peculiar advantages it offers—protection, frequent transportation, and the supply of a continual current of water, from which small organisms can be gathered for food. The branchial chamber of the crab is, indeed, a particularly favorable place for life, and is made use of by various forms. Vorticellid colonies and acinetid protozoa, polyzoa—ectoproctous and endoproctous—nemerteans, etc., are found with greater or less frequency. The considerable variation in the size and shape of the calcified plates to be noted later (see figs. 4 and 5) has probably no other significance than that it accompanies the degeneration of the plates, resulting from the fact that their function of protection is now performed by the carapace of the host. The relation of the calcified areas (*t. sc. c.*) to the whole valves (*T. S. C.*) is shown by the somewhat diagrammatic sketch (fig. 3) in which the outlines of the valves and the lines of growth are added, though in nature they are seen only under the microscope.

A barnacle removed from its host, with no piece of gill left attached will live for a considerable time with rather infrequent changes of water. One thus kept for 23

days in a flat dish molted twice and at the end seemed quite healthy. The water was changed six times.

Those crabs whose gills are heavily burdened with *Dichelaspis* have less vitality; their movements are sluggish and they are the first to die when brought into the laboratory. This reduction of vitality is not an evidence of real parasitism, but may be explained by the fact that when the cirripeds are present in large numbers much of the gill surface is occupied, gill lamellæ are fastened together, and the respiratory current retarded by them, and the barnacles have the first chance at the water. The health of the host being thus impaired, much harm results indirectly to it, in that it is rendered less able to contend with its enemies or to escape their attacks.

The following is an explanation of terms used in the description:

The *capitulum* incloses the body, and is supported upon the stalk or *peduncle*.

The juncture of the capitulum with the peduncle is regarded as the *base* of the capitulum; the angle opposite this juncture is the *apex*.

Upper means away from; *lower* toward the base.

The *rostral angle* or *umbone* is indicated by the point of union of the two segments of the scutum.

The *occludent* margin of the capitulum extends from the rostral angle to the apex.

All of the carina, except its basal portion, takes part in the *carinal* margin, which is thus approximately at right angles to the base. A tergum, therefore, has, roughly, four sides—upper, carinal, lower, and occludent.

The term *plates* or *valves* (*terga, scuta, carina*) applies to the calcified portions of the valves.

DESCRIPTION.

Darwin (1851–1854) gives this diagnosis of the genus *Dichelaspis:*

Valves 5, generally appearing like 7, from each scutum, being divided into two distinct segments, united at the rostral angle; carina generally extending up between the terga, terminating downward in an embedded disk or fork or cup. Mandible, with three or four teeth; maxillæ notched, with the lower part of the edge generally not prominent; anterior ramus of the second cirrus not thicker than the posterior ramus, nor very thickly clothed with spines; caudal appendages uniarticulate, spinose.

As will be seen from the description given below, the cirriped under consideration belongs to this genus. While the carina, which terminates downward in a fork, usually reaches only to or barely beyond the lower edges of the terga, there is considerable variation in the size and shape of the plates. To this barnacle I have given the name *Dichelaspis mülleri.** After a description of the species there will follow a comparison of *D. mülleri* with other species of the same genus.

Dichelaspis mülleri.

Capitulum barely longer than broad; basal segment of scutum parallel to lower margin of capitulum, narrower than occludent segment and about five-sixths as long; tergum divided very unequally by a notch; lower part of tergum about twice as wide as occludent segment of scutum; carina terminating downward in a fork; mandible with four teeth.

The capitulum is less than $1\frac{1}{2}$ times as long as broad (fig. 2), generally about half as thick as long, sometimes more compressed. In two of the largest specimens the capitula were 3^{mm} in width by $4\frac{1}{2}^{mm}$ in length. Others of a much more usual shape were 3^{mm} by $3\frac{1}{2}^{mm}$. These were unusually large.

The peduncle is $1\frac{1}{2}$ to 3 times as long as the capitulum, but one specimen was found with a capitulum 4^{mm} in length and peduncle 40^{mm} in length. The peduncle is translucent, except when colored by the ova, which, when present, give to a greater or less portion of the peduncle a pink color.

* Named after Fritz Muller, who says in his "Facts and Arguments for Darwin" (English translation, 1869, p. 137) that he has met with a species of *Dichelaspis* in the branchial cavity of *Lupa dicantha* (*Callinectes hastatus* formerly included under this name). He does not describe the form, which may well be identical with the Beaufort species.

The plates are small and well removed from one another. Each *scutum* (fig. 2) is composed of two segments united at the umbone by an uncalcified flexible portion; the occludent segment extends parallel and close to the occludent margin of the capitulum; is widest in the middle, where it is about half as wide as the lower part of the tergum; is narrower near the umbone, and at its upper end is always more or less pointed. The point is directed toward the notch in the tergum and reaches to or a little beyond the lower edge of that plate. Between this segment and the basal segment, which lies parallel to the base of the capitulum, is an angle varying from 70° to nearly 90°. The basal part is narrower and about five-sixths as long as occludent portion, is of a more uniform width, and, though often ending rather bluntly, is usually pointed. It may not reach quite to the points of the prongs of carina, or may overlap them as much as two-thirds their length. One scutum was found with a third narrower segment between the other two and directed toward the upper end of the carina.

Each *tergum* bears a notch on the occludent margin (figs. 2, 4, and 5). If the notch is measured from its apex to the tip of the smaller, occludent portion of the plate, its depth is generally about one-sixth (though it may be one-third) the length of the tergum or less. The lower end of the tergum is in width usually one-half (one-third to three-fourths) the length of the plate; generally it has a smooth outline, though sometimes a little jagged or with a notch. The carinal margin is usually slightly concave; this side, too, sometimes bears more or less of a notch. The upper end is blunt and rounded. Length of tergum two-thirds that of scutum, or one-third that of capitulum. That the two terga of the same individual are not necessarily just alike is shown by figs. 4 and 5; in each figure the dotted line represents the tergum of one side, the continuous line that of the other side, of one barnacle.

FIG. 3.—Diagrammatic sketch of valves.

FIG. 4.—Outlines of the two terga of an individual. × 30.

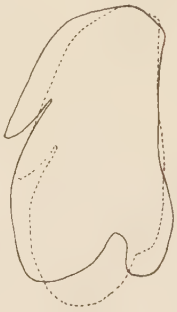


FIG. 5.—Same of another individual. × 30.

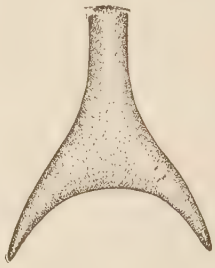


FIG. 6.—Lower part of a carina. × 30.

The *carina* (figs. 2 and 6), terminating downward in a fork, is much widened at the base of the widely separated and pointed prongs. Above the fork the carina is of very nearly uniform width. It ends bluntly, reaching to or barely beyond the lower edges of the terga; in a few cases it extends up between the terga as much as halfway. Within it is convex.

The mouth-parts are well developed. On the *labrum* are two rows of short teeth, set closely together in the middle; the *palpi* are about equal in size to the first maxillæ, and are clothed on and near the inner edge with bristles. The *mandibles* (fig. 7) have four teeth—the lower angle appears as a fifth tooth—the second being farther removed from the first than from the fourth; the lower three teeth are a little less sharp than the first; on the inferior angle are two or three very short teeth and as many stout spines; below it are a number of closely crowded slender spines; the mandible is hairy near the end and bears little tufts of hairs on its outer margin. The *second maxilla* has four spines above the notch (one is small), two slender spines in the notch, and nine or ten below (fig. 8).

The *cirri* of the first pair are removed from those of the second pair and are about half as long. Their rami are equal in length and are thickly clothed with spines. The rami of the second cirrus are of equal thickness and little shorter than those of the sixth. The *caudal appendages*, which are nearly as long as the pedicels of the sixth cirrus, are narrow and of very nearly uniform width throughout. They taper a very little at the end where is borne a tuft of 15 or 20 bristles, the longest of which are a little longer than the appendages. Sometimes other spines are found near the end.

As seems to be the case in most species of the genus, the *penis* is very large, reaching in *D. mülleri* to or beyond the second cirrus. It tapers to a point and has a tuft of short bristles on the end. On each side are scattered bristles in three rows.

COMPARISON WITH OTHER SPECIES OF DICHELASPIS.

Darwin (1851–54) gives five species under this genus, and says of their distribution:

> Eastern and western warmer oceans in the Northern Hemisphere, attached to crustacea, sea-snakes, etc.; attached to crabs at Madeira and off Borneo; to sea-snakes in the Indian Ocean. The individuals of all the species appear to be rare.

Since Darwin four species have been added to the genus: *D. darwinii* de Filippi ('61 and '61*a*), very abundant on the gills of *Palinurus vulgaris* in the Mediterranean; *D. neptuni* (MacDonald) Hoek (MacD. '69 and Hoek '83), on the gills and respiratory appendages of "*Neptunus pelagicus*, one of the swimming crabs occurring in great plenty at Moreton Bay, Australia";* *D. aymonini* Lessona and Tapparone-Canefri ('74), found on the gills of *Machrochira kaemferi* sent from Japan by Cav. Aymonin,

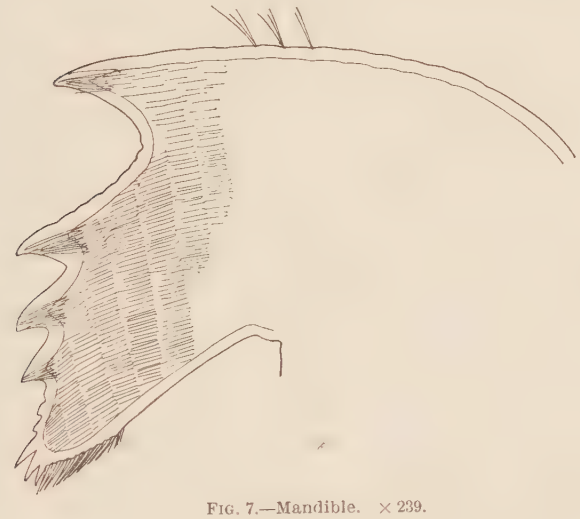


FIG. 7.—Mandible. × 239.

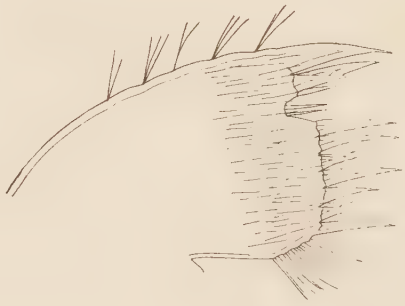


FIG. 8.—Second maxilla. × 239.

then living at Yokohama; finally, *D. sessilis* Hoek ('83), collected by the *Challenger* expedition in the Atlantic near the Azores, attached to a spine of an Echinid from 1,000 fathoms.

I reproduce in part a table for the identification of species, given by Dr. P. P. C. Hoek ('83, p. 48):

1. Carina terminating in a disk ..... *D. warwickii, D. grayii, D. pellucida*
2. Carina terminating in a fork ..... *D. neptuni, D. aymonini, D. darwinii, D. lowei*
3. Carina terminating in a cup ..... *D. orthogonia, D. sessilis*

(2) is further subdivided:

I. Basal segment of scutum directed toward centrum of capitulum ..... *D. neptuni*
II. Basal segment of scutum parallel to lower margin of capitulum.
  (*a*) Capitulum almost as long as broad [*intended for* almost as broad as long?].
    α. Tergum triangular ..... *D. aymonini*
    β. Tergum divided by a deep notch ..... *D. darwinii*
  (*b*) Capitulum more than 1½ times as long as broad ..... *D. lowei*

Thus the form of the carina, the direction of the basal segment of the scutum, and the shape of the tergum, with other points of difference, exclude this barnacle from

*MacDonald describes this form as somewhat between *Lepas* and *Dichelaspis* and gives it the name *Paradolepas neptuni;* but Hoek refers it to the genus *Dichelaspis*.

all of the above species except *D. darwinii* and *D. lowei*.* While *D. mülleri* resembles *D. lowei* in many points, it differs from it chiefly in these important respects:

(1) In shape: The capitulum of *D. lowei* is 1½ times as long as wide, while in *D. mülleri* the length barely exceeds the width. Darwin describes the capitulum as "much compressed." In *D. mülleri* it is one-half as thick as long; little compressed as compared with *Lepas*.

(2) The segments of the posterior cirri have in *D. lowei* eight pairs of main spines; in *D. mülleri* six pairs.

(3) In size of plates: The plates of our species are much smaller and farther removed from one another.

(4) The segments of the scuta are separated by an angle of °70 to 80°, instead of by an angle of 50°.

(5) The carina of *D. mülleri* does not "extend up between three-fourths of the length of the terga" (or very rarely, at most), and the prongs, instead of being separated by an angle, as in *D. darwinii*, are united by an even curve (fig. 6). This latter point, however, may be subject to variability.

D. darwinii is described by de Filippi ('61, p. 76) as extremely common as a parasite in the branchial chamber of *Palinurus vulgaris*, and is found in or near the Bay of Naples. The external resemblance to *D. mulleri* is very close, but striking differences exist between the nauplii of *D. mulleri* and those of *D. darwinii* as figured by de Filippi ('61*a*, tav. XIII, figs. 10 and 11). I need mention only that in his figure of the older nauplius (ibid., fig. 11) the frontal horns are still bent backward parallel to the body, and the spines on the appendages are no longer than those of the just-hatched nauplius (cf. figs. 10 and 11 of *D. mulleri*). Other differences in the life of the nauplii are referred to later.

Those species of *Dichelaspis* having similar habitats to that of *D. mulleri*, and apparently occurring in considerable numbers, are *D. darwinii* on lobsters of the Mediterranean, *D. neptuni* on crabs of the Southern Pacific, and *D. aymonini* on spider-crabs of Japanese waters.

SOME OBSERVATIONS ON THE DEVELOPMENT.†

The peduncle of mature individuals is generally found to be entirely, or in part, of a pink color, this color being due to the ova seen through the translucent integument. After the eggs have passed into the branchial chamber, where they are cemented together into a somewhat saddle-shaped lamella, the external pink appearance extends to the capitulum. Some idea of the condition of the eggs can thus be gained from a glance at the barnacle.

Eggs found in the ovary, which is contained in the peduncle, are roughly spherical in shape. Before passing out of the ovary they attain a diameter of about 0.1 mm.; under a high power such an egg is faintly pink in color, appearing light yellow near the circumference.

When laid the eggs are kept in the branchial chamber, where the first segmentation stages are found. The cleavage begins as total and unequal. Eggs were observed

* *D. lowei* Darwin. Madeira; attached to a rare brachyurous crab; very rare (Darwin, 1851–54).

† In the terminology of the following description of developmental stages, Korschelt & Heider's text-book ('99, pp. 209–219) and Hoek's report ('84) have been followed. The figures and descriptions in the former are of *Balanus* and of different species of *Lepas*, in the latter of a species of *Lepas*.

that had undergone only the first cleavage; as compared with the ovarian egg they were elongate, narrowed somewhat, and not much pointed at the future posterior end. As the embyro nauplius within is developed the egg becomes more pointed at this end and more square-shouldered at the other.

To understand the arrangement of the nauplial appendages in the egg, fig. 10 of the nauplius as just hatched should be compared with the egg-nauplius of fig. 9. The latter figure is a ventral view of an egg nearly ready for hatching. The entire second appendage with its two rami is seen (figs. 9 and 10, II, II*a*, II*b*), but the third appendage (see fig. 10, III, etc.) is completely hidden in this view by the overlapping second. The first appendage, too, is folded behind the second so that only its proximal portion is seen (fig. 9, I). The œsophagus apparently arches

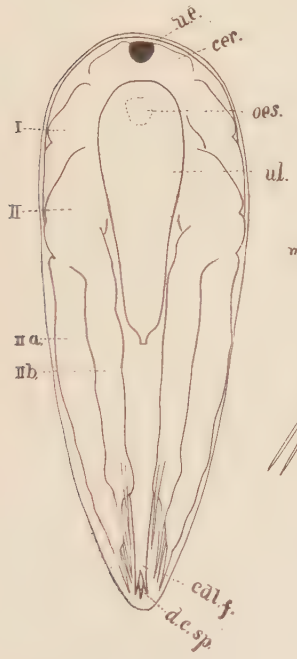


FIG. 9.—Egg nauplius. Ventral view. × 343.

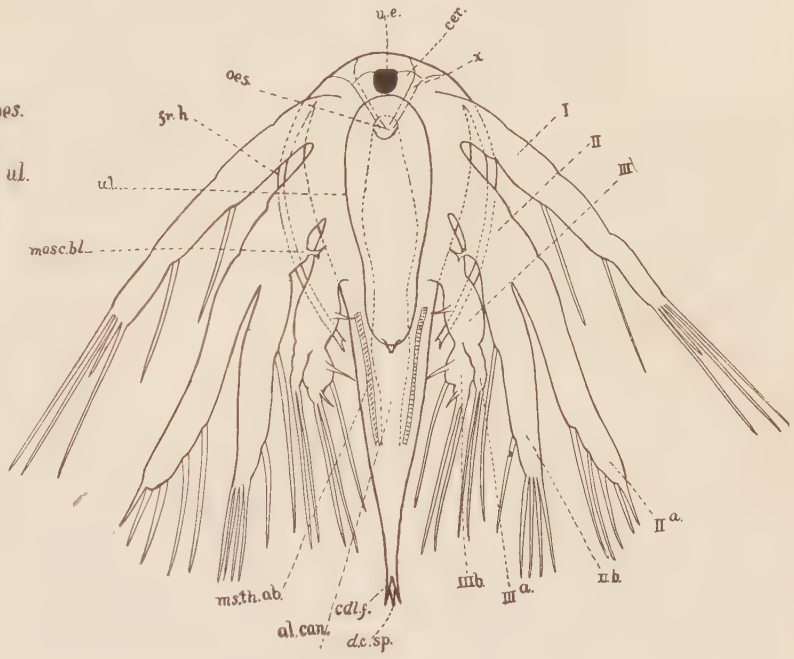


FIG. 10.—Nauplius before the first molt. Ventral view. × 343.

over ventralward, so as to open somewhat on the ventral surface of the large "upper lip" (*u.l.*), the œsophagus being seen in optical cross-section at *oes*. The large nauplius eye (*u.e.*) is closely approximated to the brain (*cer.*). At the posterior end the point of the dorso-caudal spine (*d. c. sp.*) is seen just dorsal to the caudal fork (*cdl. f.*), which terminates the thoraco-abdominal region of the body.

By selecting barnacles whose capitula are tolerably well filled with eggs, and teasing them on a slide, eggs are frequently found from which the nauplius is in the act of hatching. In several cases observed under the microscope the process was as follows: The appendages are pressed out against the shell, while the caudal end of the body is bent ventrally and anteriorly against the shell. Then while the appendages and body are pushed anteriorly as much as possible, the caudal fork slips posteriorly along the shell. These alternate movements, bracing first with the appendages, then

with the caudal part, bring pressure to bear on the anterior end of the shell and on other parts. Rupture was never observed to take place elsewhere than at the anterior end. When the shell has ruptured, with the leverage afforded on all sides, the larva is half out in a second or two; then with a single effort the shell is slipped off from the ends of the appendages and the nauplius swims freely about.

The nauplius in this stage (fig. 10) measures 0.213^{mm} in length. Of the three pairs of swimming appendages the two posterior are biramous, the rami of the third being very short. The first appendage bears 6 spines; the second, 5 and 6 on the anterior and posterior rami, respectively, besides the rudiment of the "masticatory blade" (*masc. bl.*) on the protopodite; the third bears 2 on the anterior ramus, 3 on the posterior, and 2 or 3 short spines on the protopodite and posterior ramus. The spines are straight and without branches that could be seen with the power used.

In addition to the other parts referred to in the description of the egg-nauplius, the alimentary canal (*al. can.*) can here be traced for the greater part of its course. Alongside of it are seen two stout muscles (*ms. th. ab.*) attached anteriorly and dorsally to the carapace in the region of the third appendage; posteriorly they seem to be inserted on the ventral side of the thoraco-abdominal part, and I assume them to be the means of the antero-ventral flexures of that section of the body observed in the act of hatching, and when the nauplius is kept from swimming by light pressure on the cover-glass. The parts indicated by *x* are perhaps muscles to the mouth region, but they were not so clear that muscular structure was evident. The position of the long frontal horns (*fr. h.*) bent posteriorly subparallel to the sides of the body is characteristic of this stage of the nauplius.

To obtain nauplii for study or preservation, ripe-looking barnacles may be selected and teased as described above. It was found better, however, to keep one or two dishes of water, each containing thirty or forty barnacles; the water need be changed only every two or three days. The nauplii aggregate at the surface and toward the brightest light, and can be obtained at almost any time, but, as the first molt occurs very soon, they are almost all in the second stage. De Filippi states that the nauplii of *D. darwinii* remain near the ovisacs for a long time, undergoing further development there ('61, p. 75, and '61*a*, p. 203). The first nauplii of *D. mulleri* often at least, probably as a rule, leave the branchial chamber early, undergoing the first molt outside. Washing out the gill chamber of the crab has never yielded more than a very few nauplii; when they pass from the capitulum of the parent they must be carried at once out of the crab's gill chamber.

The length of time between the hatching and the first molt was not definitely determined, but it was evidently very short—probably usually within an hour. In one case, when a barnacle was teased on a slide and nauplii in the act of hatching were found in the drop on the slide and others already free, two or three vigorous larvæ of the first stage (fig. 10) were transferred to a watch glass of water. Fifteen minutes later a nauplius was observed to have the frontal horns projecting forward, to have the appendages placed parallel to the axis of the body, and to be evidently longer than when first observed. The appendages were pressed more and more closely against the sides, and slight twitching motions of the body and appendages—apparently shrugging first one shoulder, then the other—were accompanied by a gradual lengthening of the body to 0.387^{mm}, by which time it could be seen that the

nauplius was in the act of molting. The dorso-caudal spine and the thoraco-abdominal process could be seen to evaginate as they were drawn out from the old cuticle. In a short time the appendages and body were out except for the long spines; more pronounced movements soon freeing these, the molt was completed. The nauplius in this stage, represented by fig. 11, measures, from the anterior profile of the body to

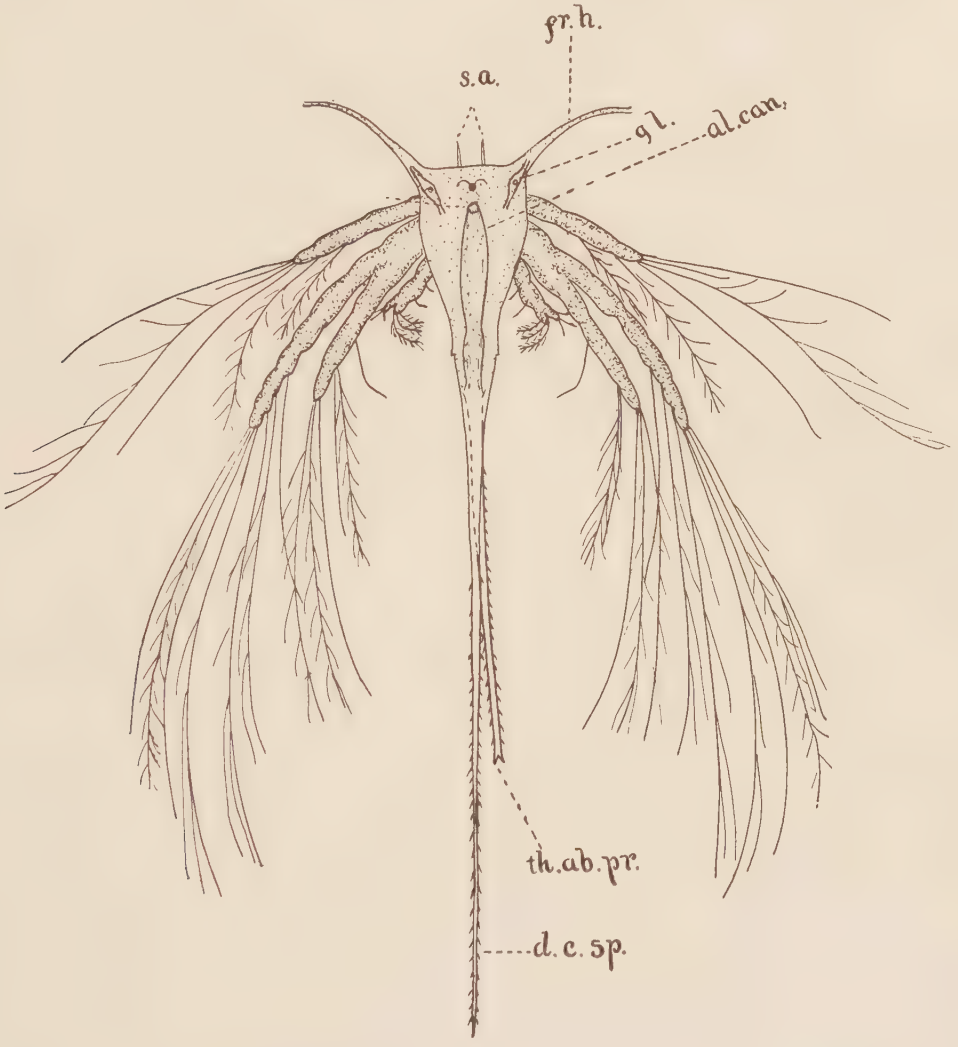


FIG. 11.—Nauplius after first molt. Dorsal view. × 140.

the end of the dorso-caudal spine, 82^{mm}, or about four times its length in the preceding stage. Occasionally a nauplius is found with the evagination of the dorso-caudal spine incomplete, so that the latter appears to become abruptly smaller at some point.

In fig. 11 the position of the "frontal horns" should be noted, as well as the presence of the sensory appendages (*s. a.*) projecting from underneath the head between the frontal horns. Most of the spines are branched; the dorso-caudal spine

(*d. c. sp.*) and the thoraco-abdominal process (*th. ab. pr.*) are barbed. The alimentary canal can be traced. At *gl* is seen the gland cell produced into the frontal horn.

Fig. 12 is a more enlarged drawing of the under surface of the body. The large "upper lip" bears a row of setæ on each side of its distal portion. At the distal end of this row there is a group of setæ about twice as long as the others. Along the axis of the lip there is a band (muscle? or gland?) which loses itself in the horseshoe-shaped dark area about the mouth region. The stout masticatory blade (*masc. bl.*) on the protopodite of the second appendage is to be observed.

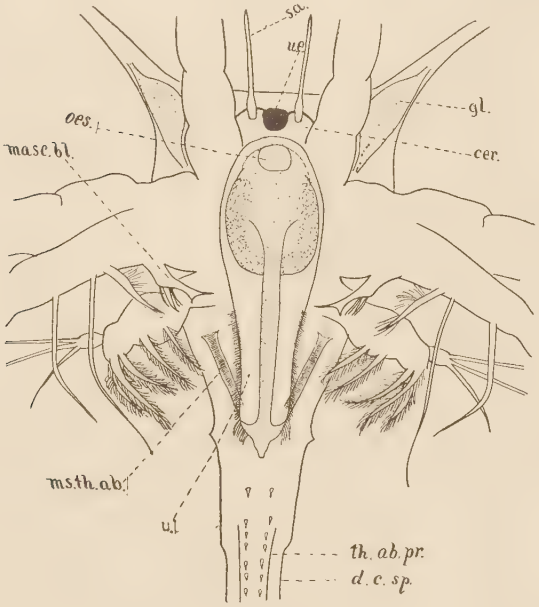


FIG. 12.—Same as fig. 11. Ventral view of body. ×280.

Fig. 13 gives a lateral view of the anal region. The alimentary canal is very much reduced in its most posterior part. The dorso-caudal spine arises just dorsal to the anus (*a*) and the thoraco-abdominal process immediately ventral. The point of insertion of the large muscle previously referred to (*ms. th. ab.*) can be seen, and just at that place there seems to be an articulation, but no observations as to the actual place of flexure were made on the living nauplius.

Several methods were tried to raise or obtain older stages of the nauplius, but with scant success. It was found that the nauplii of the smooth *Balanus* barnacle growing on the carapace of the crab could be raised to the cypris stage by keeping them in an aquarium jar of water, to which was added every day or two some sediment from another jar containing a culture of diatoms, a method suggested by Dr. Caswell Grave. The interval between the first and second molts and that between the second and third molts were, with *Balanus*, one to two days each. This and other aquarium methods were used with *Dichelaspis*, but only once was a third stage reached. In this case the aquarium was started August 22; on August 29 the nauplii were found to have undergone at least a second molt; they differed from the nauplii of the second stage little, except in size, the length having increased to 1.13^{mm} with the other proportions likewise larger.*

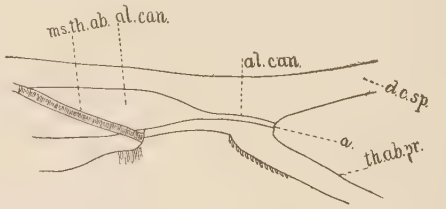


FIG. 13.—Same as fig. 11. Lateral view of posterior part of alimentary canal, etc. ×280.

* Professor de Filippi states that he failed to get the nauplii of *D. darwinii* further than the second stage of their development, and he argues from this and from other facts (form of the larva, means of locomotion, etc.) that the nauplial life is very long ('61, p. 75, and '61*a*, p. 205). But it is quite possible that further effort with Grave's method will show that the metamorphosis does not take an exceptional length of time.

In two or three crabs having a large number of barnacles of all sizes, minute white specks on the gills, when examined with a lens, proved to be attached cypris or stages between the attached cypris and the typical lepadide form.

Fig. 14 is a sketch made from an attached cypris that had been mounted in balsam; the gill had been torn from the adhering antennæ (*ant.*). The valves of the very convex and bilaterally compressed shell are continuous dorsally (*sh.*); their ventral edges are connected by the adductor muscle (*ms. ad.*) and are apposed except where the adhering antennæ are protruded in front, and posteriorly where the branchial opening, through which the thoracic feet (*th. l. I, VI*) are protruded, admits the passage of water into and out of the branchial chamber. The shell is lined by the mantle (*ml.*); anteriorly, between the mantle and the shell is seen a thick layer of loose tissue (*y*), which is perhaps a thickening of the mantle, or possibly is due to imperfect preservation; while it is not figured by Hoek or Claus (in Korsheldt & Heider) it is in all of my specimens. The dorsal infolding (*inv. d.*), separating the part that is to be the capitulum from the portion from which the peduncle is derived,

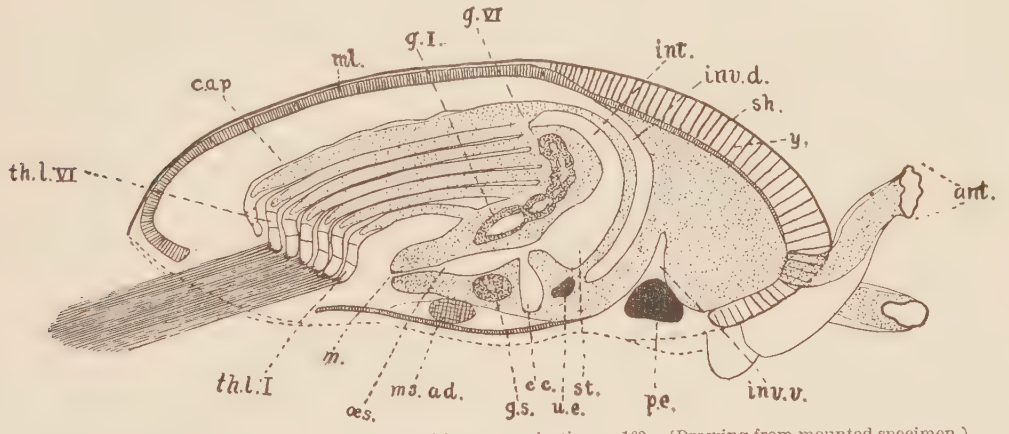


Fig. 14.—Attached cypris. Optical section, with some projections ×163. (Drawing from mounted specimen.)

is well developed. Just anterior to this is the ventral invagination (*inv. v.*), causing the peduncular portion to be bent upon itself. In this infold are the large paired eyes (*p. e.*) left behind by the withdrawal of the stalk integument, but still attached to the cuticle, and later to be thrown off (Korsheldt & Heider '99, p. 218). The unpaired nauplius eye (*u. e.*) is seen near the ventral end of the dorsal invagination, instead of anterior to the cæca as in *Lepas* (Claus's figure of the cypris of *Lepas pectinata* in K. & H. '99, p. 216). The mouth at the top of the "oral cone" leads by the œsophagus (*œs.*) into the enlarged stomach (*st.*) from which the intestine (*int.*) proceeds. Opening into the œsophagus are a pair of cæca, *cc*, (Hoek); in Claus's figure a similarly placed cavity is called the liver. Ventral to the alimentary canal is seen the chain of thoracic ganglia (*g. I* to *g. VI*) without commissures; the first is much the largest. Just above the œsophagus from this one is the supraœsophageal ganglion (*g. s.*).

Specimens in all stages of the metamorphosis from the attached cypris to the perfect lepadide adult can be found on the crab gill.

ABBREVIATIONS USED WITH FIGURES.

a .....anus.
al. can ....alimentary canal.
ant .....adhering antennæ.
c.....carina.
cc.....cæcum.
c. ap .....caudal appendage.
cap .....capitulum.
cdl. f.....caudal fork.
cer.....brain.
d. c. sp ....dorso-caudal spine.
fr. h.....frontal horn.
g. I, g. VI .ventral ganglia.
gl .....gland cell.
g. s.....supraœsophageal ganglion.
int.....intestine.
inv. d ....dorsal invagination.
inv. v ....ventral invagination.
m.....mouth.
masc. bl ..masticatory blade.
ml .....mantle.
ms. th. ab.thoraco-abdominal muscle. (?)
ms. ad ...adductor muscle.
œs .....œsophagus.
ov .....ovary.
ped .....peduncle.
p. e .....paired (cypris) eye.
s. a .....sensory appendage.
sc.....scutum.
sh.....shell.
st .....stomach.
t.....tergum.
th. ab. pr ..thoraco-abdominal process.
th. l, I–VI .thoracic limbs.
u. e .....unpaired (nauplius) eye.
u. l.....upper lip.
T, S, C ....uncalcified valves (terga, scuta, carina).
x, y .....(see pages 408 and 411, respectively.)
I, II, III..first, second, and third nauplial appendages.
IIa, IIb...anterior and posterior rami of second appendage.
IIIa, IIIb.anterior and posterior rami of third appendage.

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MARINE PROTOZOA FROM WOODS HOLE.

BY

GARY N. CALKINS.

Contributions from the Biological Laboratory of the U. S. Fish Commission,
Woods Hole, Massachusetts.

MARINE PROTOZOA FROM WOODS HOLE.

By GARY N. CALKINS,
Department of Zoology, Columbia University.

Comparatively little has been done in this country upon marine Protozoa. A few observations have been made by Kellicott, Stokes, and Peck, but these have not been at all complete. With the exception of Miss Stevens's excellent description of species of *Lichnophora* I am aware of no single papers on individual forms. Peck ('93 and '95) clearly stated the economic position of marine Protozoa as sources of food, and I need not add to his arguments. It is of interest to know the actual species of various groups in any locality and to compare them with European forms. The present contribution is only the beginning of a series upon the marine Protozoa at Woods Hole, and the species here enumerated are those which were found with the algæ along the edge of the floating wharf in front of the Fish Commission building and within a space of about 20 feet. Many of them were observed in the water and algæ taken fresh from the sea; others were found only after the water had been allowed to stand for a few days in the laboratory. The tow-net was not used, the free surface Protozoa were not studied, nor was the dredge called into play. Both of these means of collecting promise excellent results, and at some future time I hope to take advantage of them.

My observations cover a period of two months, from the 1st of July to the 1st of September. During that time I was able to study and describe 72 species representing 55 genera, all from the limited space mentioned above. In addition to these there are a few genera and species upon which I have insufficient notes, and these I shall reserve until opportunity comes to study them further.

I take this opportunity to express my thanks to Dr. Hugh M. Smith for many favors shown me while at Woods Hole.

In dealing with these marine forms from the systematic standpoint, two courses are open to the investigator. He may make numerous new species based upon minor differences in structure, or he may extend previous descriptions until they are elastic enough to cover the variations. The great majority of marine Protozoa have been described from European waters, and the descriptions are usually not elastic enough to embrace the forms found at Woods Hole. I have chosen, however, to hold to the conservative plan of systematic work, and to make as few new species as possible, extending the older descriptions to include the new forms.

The different classes of Protozoa, and orders within the classes, are distributed more or less in zones. Thus the Infusoria, including the Ciliata and the Suctoria, are usually littoral in their habitat, living upon the shore-dwelling, or attached, water plants and upon the animals frequenting them. It is to be expected, therefore, that in forms here considered there should be a preponderance of Infusoria. Flagellated forms are also found in similar localities, but on the surface of the sea as well; hence the number described in these pages is probably only a small proportion of the total number of Mastigophora in this region. The Sarcodina, including the Foraminifera and the Radiolaria, are typically deep-sea forms and would not be represented by many types in the restricted locality examined at Woods Hole. Two species, *Gromia lagenoides* and *Truncatulina lobatula*, alone represent the great order of Foraminifera, while the still larger group of Radiolaria is not represented at all.

The Protozoa described are distributed among the different orders as follows:*

Class SARCODINA.
Subclass RHIZOPODA.
Order AMŒBIDA. Page.
1. *Amœba guttula* Duj 417
2. *Amœba* sp 417
3. *Trichosphærium sieboldi* Schn 418
Order RETICULARIIDA.
Suborder IMPERFORINA.
4. *Gromia lagenoides* Gruber 419
Suborder PERFORINA.
5. *Truncatulina lobatula* Walker & Jacob 420
Subclass HELIOZOA.
Order APHROTHORACIDA.
6. *Actinophrys sol* Ehr 420
Order CHLAMYDOPHORIDA.
7. *Heterophrys myriapoda* Archer 421
Class MASTIGOPHORA.
Subclass FLAGELLIDIA.
Order MONADIDA.
8. *Mastigamœba simplex*, n. sp 422
9. *Codonœca gracilis*, n. sp 423
10. *Monas* sp 423
Order CHOANOFLAGELLIDA.
11. *Monosiga ovata* S. Kent 424
12. *Monosiga fusiformis* S. Kent 424
13. *Codonosiga botrytis* (Ehr.) J. Cl 424
Order HETEROMASTIGIDA.
14. *Bodo globosus* Stein 425
15. *Bodo caudatus* (Duj.) Stein 425
16. *Oxyrrhis marina* Duj 425
Order EUGLENIDA.
17. *Astasia contorta* Duj 426
18. *Anisonema vitrea* Duj 426
Order SILICOFLAGELLIDA.
19. *Distephanus speculum* Stöhr 427
Subclass DINOFLAGELLIDIA.
Order ADINIDA.
20. *Exuviælla lima* Cienk 428
21. *Exuviælla marina* Cienk 429
Order DINIFERIDA.
22. *Gymnodinium gracile* Bergh 429
23. *Glenodinium cinctum* Ehr 430
24. *Glenodinium compressa*, n. sp 430
25. *Peridinium digitale* Pouchet 431
26. *Peridinium divergens* Ehr 431
27. *Ceratium tripos* Nitsch 432
28. *Ceratium fusus* Ehr 432
29. *Amphidinium operculatum* Clap. & Lach 432
Class INFUSORIA.
Subclass CILIATA.
Order HOLOTRICHIDA.
Family ENCHELINIDÆ. Page.
30. *Lacrymaria lagenula* Cl. & Lach 433
31. *Lacrymaria coronata* Cl. & Lach 434
32. *Trachelocerca phœnicopterus* Cohn 435
33. *Tiarina fusus* Cl. & Lach 437
34. *Mesodinium cinctum*, n. sp 436
Family TRACHYLINIDÆ.
35. *Lionotus fasciola* Ehr 438
36. *Loxophyllum setigerum* Quenn 438
Family CHLAMYDODONTIDÆ.
37. *Nassula microstoma* Cohn 440
38. *Chilodon cucullulus* Müll 441
39. *Dysteria lanceolata* Cl. & Lach 441
Family CHILIFERIDÆ.
40. *Frontonia leucas* Ehr 442
41. *Colpidium colpoda* Ehr 443
42. *Uronema marina* Duj 444
Family PLEURONEMIDÆ.
43. *Pleuronema chrysalis* Ehr 444
44. *Pleuronema setigera*, n. sp 445
45. *Lembus infusionum*, n. sp 446
46. *Lembus pusillus* Quenn 446
Family OPALINIDÆ.
47. *Anoplophrya branchiarum* Stein 447
Order HETEROTRICHIDA.
Family BURSARIDÆ.
48. *Condylostoma patens* Müll 449
Family HALTERIIDÆ.
49. *Strombidium caudatum* From 450
Family TINTINNIDÆ.
50. *Tintinnopsis beroidea* Stein 451
51. *Tintinnopsis davidoffi* Daday 451
Order HYPOTRICHIDA.
Family PERITROMIDÆ.
52. *Peritromus emmæ* Stein 452
Family OXYTRICHIDÆ.
53. *Epiclintes radiosa* Quenn 453
54. *Amphisia kessleri* Wrzes 454
Family EUPLOTIDÆ.
55. *Euplotes charon* Ehr 455
56. *Euplotes harpa* Stein 455
57. *Diophrys appendiculatus* Stein 456
58. *Uronychia setigera*, n. sp 457
59. *Aspidisca hexeris* Quenn 458
60. *Aspidisca polystyla* Stein 458

*This classification includes only the orders and families represented at Woods Hole.

Class INFUSORIA—Continued. Page.
Subclass CILIATA—Continued.
Order PERITRICHIDA.
Family LICHNOPHORIDÆ.
61. *Lichnophora macfarlandi* Stevens 459
Family VORTICELLIDÆ.
62. *Vorticella marina* Greeff 461
63. *Vorticella patellina* Müller 461
64. *Zoothamnium elegans* D'Udek 461
65. *Cothurnia crystallina* Ehr 462
66. *Cothurnia nodosa* Cl. & Lach 463
67. *Cothurnia imberbis* Ehr 462

Class INFUSORIA—Continued. Page.
Subclass SUCTORIA.
Family PODOPHRYIDÆ.
68. *Podophrya gracilis*, n. sp 463
69. *Ephelota coronata* Wright 464
Family ACINETIDÆ.
70. *Acineta divisa* Fraip 465
71. *Acineta tuberosa* Ehr 465
Family DENDROSOMIDÆ.
72. *Trichophrya salparum* Entz 466

Genus AMŒBA Auct.

The pseudopodia are lobose, sometimes absent, the body then progressing by a flowing movement; the body consists of ectoplasm and endoplasm, the latter being granular and internal, the former hyaline and external. There is always one nucleus and one vacuole, but both may be more numerous. Reproduction takes place by division or by spore-formation. Fresh-water and marine.

FIG. 1.—*Amœba guttula.*

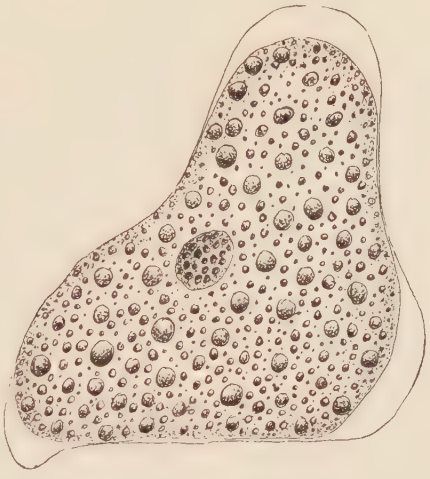


FIG. 2.—*Amœba* sp.

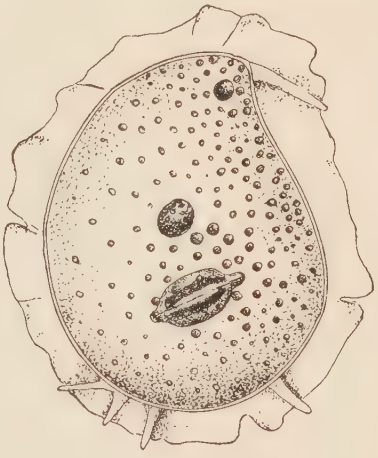


FIG. 3.—*Trichosphærium sieboldi.*

Amœba guttula Duj. Fig. 1.

A minute form without pseudopodial processes, extremely hyaline in appearance, and characterized by rapid flowing in one direction. The body is club-shape and moves with the swollen end in advance. A comparatively small number of large granules are found in the swollen portion, while the smaller posterior end is quite hyaline. Contractile vacuole absent, and a nucleus was not seen. Frequent in decomposing vegetable matter. Length 37μ. Traverses a distance of 160μ in one minute.

The fresh-water form of *A. guttula* has a vacuole, otherwise Dujardin's description agrees perfectly with the Woods Hole forms.

Amœba? Fig. 2.

A more sluggish form than the preceding, distinguished by its larger size, its dense granulation, and by short, rounded pseudopodia, which, as in *Amœba proteus*, may come from any part of the body. A delicate layer of ectoplasm surrounds the granular endoplasm, and pseudopodia formation is eruptive, beginning with the accumulation of ectoplasm. Movement rapid, usually in one direction, but may be backwards or sideways, etc. Contractile vacuole absent; the nucleus is spherical and contains many large chromatin granules. Length 80μ; diameter 56μ.

Genus TRICHOSPHÆRIUM Schneider '78.

Synonym: *Pachymyxa hystrix* Gruber.

Marine rhizopods, globular or irregular in form, and slow to change shape. Dimorphic. Both forms multinucleate during vegetative life. Pseudopodia are long, thin, and thread-form, with rounded ends. Their function is neither food-getting nor locomotion, but probably tasting. The plasm of both forms is inclosed in a soft gelatinous membrane. In one form the jelly is impregnated with needles of magnesium carbonate (Schaudinn), but these are absent in the other form. The membrane is perforated by clearly defined and permanent holes for the exit of the pseudopodia. Reproduction occurs by division, by budding or by fragmentation, but the parts are invariably multinucleate. At the end of vegetative life the needle-bearing form fragments into numerous mononucleate parts; these develop into adults similar to the parent, but without the spines. At the end of its vegetative life this new individual fragments into biflagellated swarm-spores which may conjugate, reproducing the form with needles. Size up to 2 mm.

FIG. 4.—*Gromia lagenoides.*

Trichosphærium sieboldi Schneider. Fig. 3.

With the characters of the genus. A form which I have taken to be a young stage of this interesting rhizopod is described as follows:

A minute, almost quiescent, form which changes its contour very slowly. The membrane is cap-like and extends over the dome-shaped body, fitting the latter closely. The endoplasm is granular and contains foreign food-bodies. Nucleus single, spherical, and centrally located. Pseudopodia short and finger-form, emerging from the edge of the mantle-opening and swaying slowly from side to side or quiescent. The most characteristic feature is the presence of a broad, creeping sole, membranous in nature and hyaline in appearance. This membrane is the only evidence of ectoplasm, and it frequently shows folds and wrinkles, while its contour slowly changes with movements of body. The pseudopodia emerge from the body between this membrane and the shell margin. Contractile vacuole absent. Length 42μ, width 35μ. In decomposing seaweeds, etc.

Only one specimen of this interesting form was seen, and I hesitate somewhat in placing it on such a meager basis. It is so peculiar, however, that attention should be called to it in the hope of getting further light upon its structure and mode of life. Its membranous disk recalls the genus *Plakopus*; its mononucleate condition, its membranous disk, and the short, sometimes branched,

pseudopodia make it difficult to identify with any phase in the life-history of *Trichosphærium*. I shall leave it here provisionally, with the hope that it may be found more abundantly another time.

Genus GROMIA Dujardin '35.

(Dujardin 1835; M. Schultze '62; F. E. Schultze '74; Leidy '77; Bütschli '83; Gruber '84.)

The form is ovoid or globular, and the body is covered by a tightly fitting, plastic, chitin shell, which, in turn, is covered by a fine layer of protoplasm. The flexibility of the shell makes the form variable as in the amœboid types. The thickness of the shell is quite variable. The pseudopodial opening is single and terminal. The pseudopodia are very fine, reticulate, granular, and sharply pointed, and form a loose network outside of the shell opening. Nucleus single or multiple. Contractile vacuole is usually absent. Fresh and salt water.

Gromia lagenoides Gruber '84. Fig. 4.

This species is not uncommon about Woods Hole, where it is found upon the branches of various types of algæ. The body is pyriform, with the shell opening at the larger end. The chitinous shell

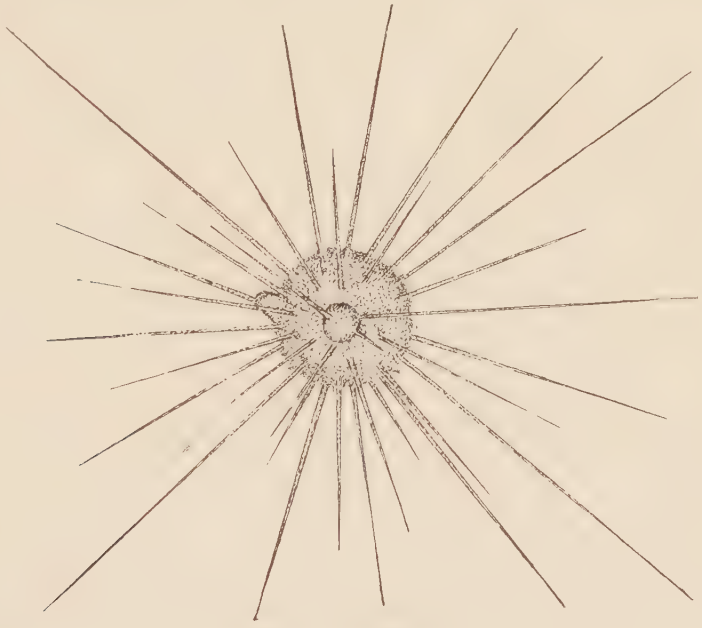


FIG. 5.—*Actinophrys sol.*

is hyaline and plastic to a slight extent, so that the body is capable of some change in shape. The shell is thin and turned inwards at the mouth-opening, forming a tube (seen in optical section in fig. 4) through which the protoplasm passes to the outside. The walls of this tube are thicker than the rest of the shell, and in optical section the effect is that of two hyaline bars extending into the body protoplasm. A thin layer of protoplasm surrounds the shell and fine, branching, pseudopodia are given off in every direction. The protoplasm becomes massed outside of the mouth-opening and from here a dense network of pseudopodia forms a trap for diatoms and smaller Protozoa. The nucleus is spherical and contains one or two large karyosomes. The protoplasm is densely and evenly granular, without regional differentiation. I have never observed an external layer of foreign particles, such as Gruber described in the original species.

Length of shell 245μ; largest diameter 125μ.

Genus TRUNCATULINA D'Orbigny.

A group of extremely variable foraminifera in which the shell is rotaline; i. e., involute on the lower side and revolute on the upper (Brady). The shell is calcareous and coarsely porous in older

forms. The characters are very inconstant, and Brady gives up the attempt to distinguish the group by precise and constant characters.

Truncatulina lobatula Walker & Jacob.

Synonyms: See Brady '84 for a long list.

"It is impossible to define by any precise characters the morphological range of the present species. Its variations are infinite." (Brady, p. 660.)

This very common form, which occurs in all latitudes, was found frequently among the algæ at Woods Hole. Its characters are so difficult to define that for the present I shall limit my record to this brief notice. Size of shell 230μ by 270μ.

Genus ACTINOPHRYS Ehr.

The body is spherical and differentiated into granular endoplasm and vacuolated ectoplasm, but the zones are not definitely separated. There is one central nucleus and usually one contractile

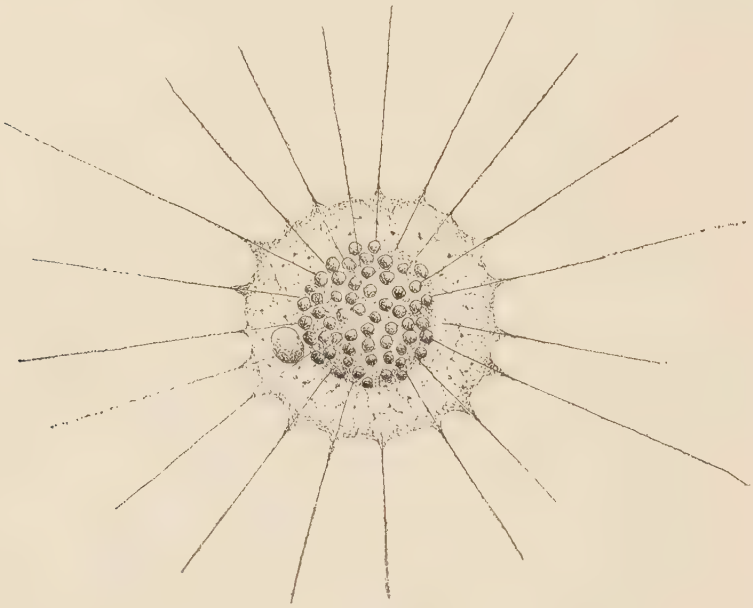


FIG. 6.—*Heterophrys myriapoda.*

vacuole. The pseudopodia have axial filaments that can be traced to the periphery of the nucleus. Fresh and salt water.

Actinophrys sol Ehr., variety. Fig. 5.

Synonyms: See Schaudinn '95.

The diameter is about 50μ; the vacuolated ectoplasm passes gradually into the granular endoplasm. This is the characterization given *A. sol* by Schaudinn, and it applies perfectly to the fresh-water forms. If I am correct, however, in placing an *Actinophrys*-like form found at Woods Hole in this species, the description will have to be somewhat modified. In this form (fig. 5) there is no distinction between ectoplasm and endoplasm, and there is an entire absence of vacuoles. The nucleus is central, and axial filaments were not seen. The single specimen that I found looked much like a Suctorian of the genus *Sphærophrya*, but the absence of a firm cuticle and the presence of food-taking pseudopodia with granule-streaming makes it a very questionable Suctorian, and I place it here until further study throws more light upon it.

Diameter of body 40μ; length of pseudopodia 120 to 140μ.

Genus HETEROPHRYS Archer.

The body is globular with but slight differentiation into ectoplasm and endoplasm; one nucleus in the latter; contractile vacuoles one or many; pseudopodia on all sides, thin, and with peripheral granule-streaming; surrounded by a globular, rather thick coat of jelly, which is hyaline inside and granular on the periphery. Fresh and salt water.

Heterophrys myriapoda Archer. Fig. 6.

Synonym: *H. marina* Hert. & Less. '74.

Diameter 25 to 80μ; pseudopodia twice as long as the body diameter; the plasm often contains chlorophyl bodies (Zoochlorella). The granular part of the gelatinous layer is thick (up to 10μ). The spine-like processes are very thin and short. (Schaudinn '95.) The marine form found at Woods Hole probably belongs to this species, as described by Schaudinn. The short pseudopodia which give to the periphery a fringed appearance are quite regularly placed in connection with the pseudopodia. The latter are not so long as twice the body diameter, the longest being not more than equal to the diameter of the sphere. The body inside of the gelatinous covering is thickly coated with bright yellow cells similar to those on Radiolaria. The animal moves slowly along with a rolling motion similar to that described by Pènard '90, in the case of *Acanthocystis*. Diameter of entire globe 35μ; of the body without the jelly 18μ. The extremely fine granular pseudopodia are 8 to 35μ long. Common among algæ.

This form was probably meant by Peck '95, when he figured "a heliozoön."

Key to orders of Flagellidia.

Small, body usually amœboid; 1 or more flagella; no mouth	Order MONADIDA.
Small; plasmic collar around the flagellum	Order CHOANOFLAGELLIDA
With 2 or more flagella; one trails behind	Order HETEROMASTIGIDA
With 3 or more flagella, none of which trails	Order POLYMASTIGIDA
Large; firm body wall; 1 or 2 flagella; mouth or pharynx, or both	Order EUGLENIDA
Medium size; with chlorophyl, no mouth, usually colonial	Order PHYTOFLAGELLIDA.
Small; silicious skeleton; parasitic on Radiolaria or free	Order SILICOFLAGELLIDA. (One genus, *Distephanus* Stöhr), p. 427

Key to the families of Monadida.

No mouth; 1 or 2 flagella; amœboid with lobose or ray-like pseudopodia	Family *Rhizomastigidæ*
Mouth at base of single flagellum; plastic; no pseudopodia	Family *Cercomonadidæ*
One flagellum; inclosed in gelatinous or membranous cups	Family *Codonœcidæ*
One flagellum; tentacle-like process at base of flagellum; inclosed in cup	Family *Bikœcidæ*
One main flagellum and 1 or 2 accessory flagella	Family *Heteromonadidæ*

Key to marine genera of Monadida.[a]

Family *Rhizomastigidæ:*	
1. Flagellum repeatedly thrown off and reassumed	Genus **Mastigamœba* in part, p. 422
2. Flagellum never thrown off	3
3. *a.* Pseudopodia lobose	Genus *Mastigamœba*
b. Pseudopodia ray-like	Genus *Mastigophrys*
Family *Codonœcidæ:*	
1. Goblet-shaped cups adherent by stalk	Genus **Codonœca*, p. 423
Family *Heteromonadidæ:*	
1. The long flagellum vibratory	Genus **Monas*, p. 423
2. The long flagellum rigid; shorter one vibrates	Genus *Sterromonas*

Key to marine genera of Choanoflagellida.

1. Without gelatinous or membranous test	3
2. With gelatinous or membranous test	4
3. *a.* Attached forms:	
1. Without a stalk, or with a very short one	Genus **Monosiga*, p. 423
2. With a long, simple, stalk	Genus **Codonosiga*, p. 424
3. With a long, branched, stalk	Genus *Codonocladium*
b. Free-swimming	Genus *Desmarella*
4. Colonial, and with a gelatinous covering	Genus *Proterospongia*

[a] Presence at Woods Hole indicated by asterisk.

Key to families and marine genera of Heteromastigida.

1. Two flagella nearly equal in size ..... Family *Bodonidæ*
   One main and 2 accessory flagella ..... Family *Trimastigidæ*

Family *Bodonidæ:*

1. Body very plastic, almost amœboid ..... Genus * *Bodo*, p. 424
   Body not plastic; with large anterior cavity, holding flagella ..... Genus * *Oxyrrhis*, p. 425

Family *Trimastigidæ:*

1. With an undulatory membrane between accessory flagella ..... Genus *Trimastix*
   Without such membrane; flagella contained in a ventral groove while at rest ..... Genus *Costia*

Key to marine genera of Polymastigida.

1. Body flattened; ends rounded; sides hollowed; often with wing-like processes; cross section S-shaped ..... Genus *Trepomonas*
2. Body pyriform; one large asymmetrical groove; 4 flagella ..... Genus *Tetramitus*
3. Body spherical; many flagella equally distributed ..... Genus *Multicilia*

Key to families and marine genera of Euglenida.

1. With deeply-insunk pharynx; no mouth 2
   With pharynx and distinct mouth ..... Family *Peranemidæ*
2. Body plastic; usually with chromatophores and eye-spot ..... Family *Euglenidæ*
   Body plastic; no chromatophores; no eye-spot ..... Family *Astasiidæ*

Family *Euglenidæ:*

   Body *Euglena*-like, inclosed in shell with round opening for exit of flagellum ..... Genus *Trachelomonas*

Family *Astasiidæ:*

   Body with one flagellum ..... Genus * *Astasia*, p. 425

Family *Peranemidæ:*

1. Body striped; plastic; two diverse flagella ..... Genus *Heteronema*
2. Body striped; not plastic; posterior flagellum longer than the other ..... Genus * *Anisonema*, p. 426
3. Body striped; not plastic; with rod-like organ in pharynx ..... Genus *Entosiphon*

Genus MASTIGAMŒBA F. E. Schultze '75.

(Kent '81; Bütschli '86; Klebs '92; Senn 1900.)

In general the form is oval and either regular in outline or irregular through the presence of many pseudopodia. One flagellum usually quite large and distinct. Differentiation of ectoplasm and endoplasm distinct or wanting. One to several contractile vacuoles. The pseudopodia are occasionally withdrawn, and the flagellum is the sole means of locomotion. In some cases the flagellum turns into a pseudopodium, and, conversely, the pseudopodium at one end may become a flagellum (see below). In some rare cases the ectoplasm secretes a gelatinous mantle. Reproduction not observed.

Fresh and salt water.

Mastigamœba simplex, n. sp. Fig. 7.

A very small form, first seen in the flagellated stage, aroused my interest by reason of the fact that its flagellum lost its regular outline and became amœboid, turning to a pseudopodium, while at the same time other pseudopodia were protruded from different parts of the periphery. In this condition ectoplasm and endoplasm could be made out with the clearest definition. After the pseudopodia were well formed, the body became flat and closely attached to the glass slide. In a short time one of the pseudopodia became longer than the rest; the body became more swollen; the pseudopodia were gradually drawn in, with the exception of the more elongate one; this became active in movement and finer in diameter, until ultimately it formed a single flagellum at the anterior of a small monadiform flagellate. The process was repeated two or three times under my observation, so that I am convinced that it was not a developmental form of some rhizopod. Several of them were seen at different times during the summer, and they were always of the same size and form in the flagellated or amœboid condition. I did not make out their reproduction, and I shall not be satisfied that this is a good species until their life history is known.

In decaying algæ. Length 10μ.

Genus CODONŒCA James Clark '66.

(Kent '81.)

Small forms inclosed in cup or "house" of ovoid or goblet shape, colorless and probably gelatinous (chitin?) in texture, and borne upon a stalk. The monad does not completely fill the test. Contractile vacuole single, posterior.

Codonœca gracilis, n. sp. Fig. 8.

The cup is urn-shaped with a well-defined neck or collar borne upon a shoulder-like end of the body. It is hyaline, colorless, and carried upon a stalk equal in length to the cup or shorter than this. The animal does not fill the cup, nor is it attached by a filament to the latter. There is a single flagellum. The nucleus is minute and lateral in position; the contractile vacuole is in the posterior end of the body. Total length of cup and stalk 21μ; of cup alone 12μ. This minute form looked so much like a choanoflagellate that I supposed it to be one until I discovered an empty case (Fig. 8).

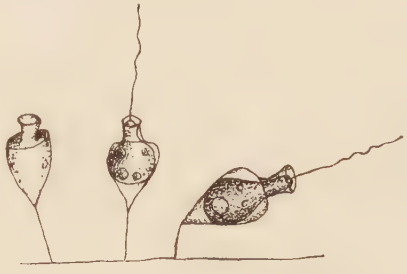


FIG. 8.—*Codonœca gracilis.*

FIG. 7.—*Mastigamœba simplex.*

Genus MONAS (Ehr.) Stein '78.

(Kent '81; Bütschli '86; Klebs '97; Senn 1900.)

The body is small, globular or oval and either free-swimming or fastened by one of the two flagella. The body is sometimes a little amœboid, with short pseudopodial processes. In addition to the main flagellum, there are usually one or two small flagella at the basis of the larger one. The nucleus is usually anterior, and one or two contractile vacuoles are present.

Monas sp. Fig. 9.

An extremely small form (3μ) attached by a thread of protoplasm—perhaps a flagellum, to algæ. The body is ovoid and the main flagellum is about four times the length of the body. The contractile vacuole is posterior. Only one specimen was seen and upon this I shall not attempt to name the species.

Genus MONOSIGA Kent '81.

(Bütschli '86; Francé '97; Senn 1900.)

Small colorless forms of Choanoflagellida, always naked and solitary. The posterior end is attached directly to the substratum, or there is a short stalk not exceeding the body in length. Kent '81 distinguished nine species, but Bütschli questioned the accuracy of many of these, and in this he was

followed by Francé '97, who recognized three species—*Monosiga ovata*, *M. fusiformis*, and *M. augustata*. Fresh and salt water.

Monosiga ovata S. Kent '81. Fig. 10.

Synonyms: *M. brevipes* S. K.; *M. consociata* S. K.; *M. limnobia* Stokes.

The individuals are unstalked or provided with a very short stalk less than the body in length. The form is spherical or ovate, broadest at the base and tapering to the extremity. The collar is somewhat variable in size. In the Woods Hole forms it was about the length of the body. Oil particles present. Contractile vacuole posterior, nucleus anterior.

Fresh and salt water. Length of body without the collar 5μ.

Monosiga fusiformis S. K. Fig. 11.

Synonyms: *M. steinii* S. K.; *M. longicollis?* S. K.

The individuals are unstalked, minute, and of a general flask-shape. The body is swollen centrally and tapers slightly at each end. There is no stalk, the body being fixed by the attenuate posterior end. There are two contractile vacuoles and one nucleus, which is situated a little above the body center. Fresh and salt water. Length without collar 9μ; length of collar 3μ.

FIG. 9.—*Monas* sp.

FIG. 10.—*Monosiga ovata.*

FIG. 11.—*M. fusiformis.*

FIG. 12.—*Codonosiga botrytis.*

Genus CODONOSIGA (Jas. Clark '67).

(Bütschli '78; Kent '81; Francé '97; Senn 1900.)

This genus, as modified by Francé, is distinguished from the preceding by the possession of an unbranched stalk much longer than the body length. The body is naked and of various shapes, and the individuals are solitary or colonial upon a single stalk. Kent '81 enumerates no less than 10 species, which were cut down by Bütschli to 1. Francé admits 4—*C. botrytis* Jas. Clark; *C. grossularia; C. pyriformis*, and *C. furcata*, all S. Kent—but regards the second and third as merely form varieties of the first.

Codonosiga botrytis (Ehr. sp.) Jas. Clark '67. Fig. 12.

Francé gives the following synonyms: *Epistylis botrytis* Ehr.; *E. digitalis?* Stein; *Zoothamnium parasitica?* Stein; *Anthophysa solitaria* Fresenius; *Codonosiga pulcherrima* Jas. Clark; *Monosiga gracilis* S. Kent; *M. globulosa* S. Kent; *Codonosiga pyriformis* Kent; *C. grossularia* Kent; (Francé).

The individuals are small and provided with a long unbranched, or terminal, simply split stalk. The individuals are single or colonial. The Woods Hole form measured 22μ over all; the body was 5μ, the collar 3μ, and the stalk 14μ. No colonies were seen, and only a few individuals upon red algæ.

Genus BODO (Ehr.) Stein.

(Stein '59, Bütschli '83, Klebs '92; Senn 1900.)

The body is naked, usually amœboid in its changes, and provided with two flagella, one of which is usually trailed along under and behind the animal. The anterior end is usually pointed, with the flagella arising from a minute depression; the posterior end is rounded. Specific characters very difficult to analyze. Fresh and salt water.

Bodo globosus Stein. Fig. 13.

The body during movement is globular or ovoid, without any anterior process. The trailing flagellum is invariably much longer than the vibratory one. The contractile vacuole lies in the anterior half of the body. Solid food particles are taken in near base of flagella.

Length of body 9 to 12μ; diameter 8 to 11μ. Common.

Bodo caudatus (Duj.) Stein. Fig. 14.

Synonyms: *Amphimonas caudatus* Duj.; *Diplomastix caudata* Kent.

The body is variable in shape, but usually flattened and pointed posteriorly. An anterior process is almost always present, and below this the flagella are inserted in a minute depression. The contractile vacuole is close to the base of the flagella. The flagella are about the same size, the anterior one usually somewhat longer. **Common.** Length 12 to 18μ.

This species was seen by Peck '95 and described as a small flagellate.

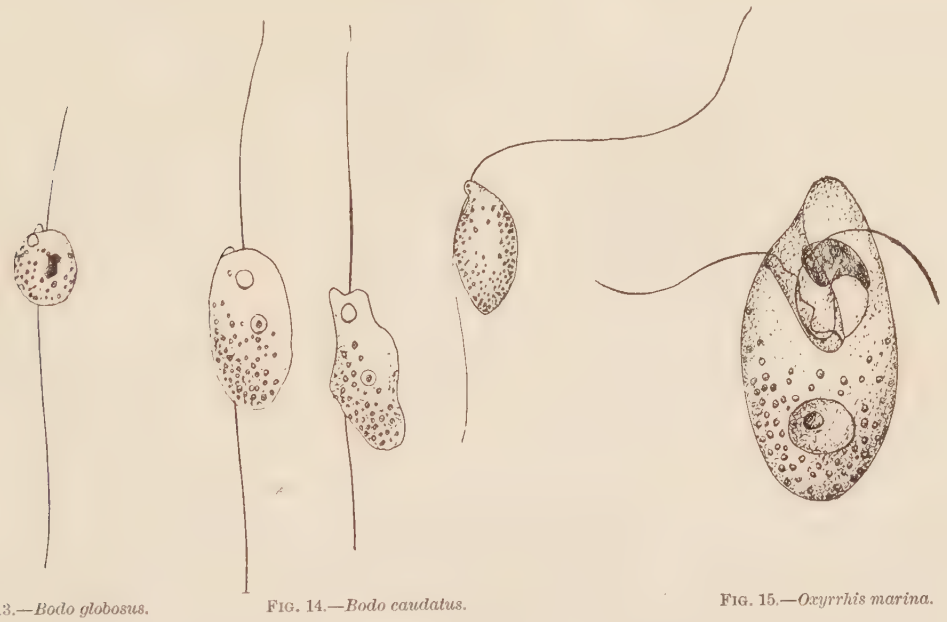


FIG. 13.—*Bodo globosus.* FIG. 14.—*Bodo caudatus.* FIG. 15.—*Oxyrrhis marina.*

Genus OXYRRHIS Duj.

(Kent '81; Bütschli '86; Klebs '92; Senn 1900.)

Medium-sized forms, somewhat oval in shape, with a rounded posterior end. The anterior end is continued dorsally in a somewhat attenuate pointed process. At the base of this process is a large cavity or funnel, on the dorsal wall of which, or on a projection from this wall, are two equal-size flagella. When at rest, the flagella are directed backwards. The nucleus is central. In moving, the posterior end is invariably in advance. This genus is exceptional among Mastigophora in that division is transverse instead of longitudinal.

Oxyrrhis marina Duj. Fig. 15.

With the characters of the genus. Contractile vacuole not seen. Length 28 to 40μ.

Genus ASTASIA Ehr.

Flagellates with one flagellum, a spindle-form body and a high degree of plasticity, the contour constantly changing. A distinct, usually striped cuticle is invariably present. "Eye-spots" are absent. Fresh and salt water.

Astasia contorta Duj. Fig. 16.

Astasia inflata Duj. '41.

The body is colorless, transparent, and flexible. It is largest in the center, thence tapering at the two extremities. The surface of the cuticle is obliquely striated, giving to the animal a distinctly twisted appearance. The contractile vacuole is in the anterior neck-like portion of the body. The flagellum is inserted in a distinct œsophageal tube, into which the contractile vacuole empties. This tube is continued into a deeper pharyngeal apparatus of unknown function.

Common in decaying algæ. Length 60μ; greatest diameter 30μ.

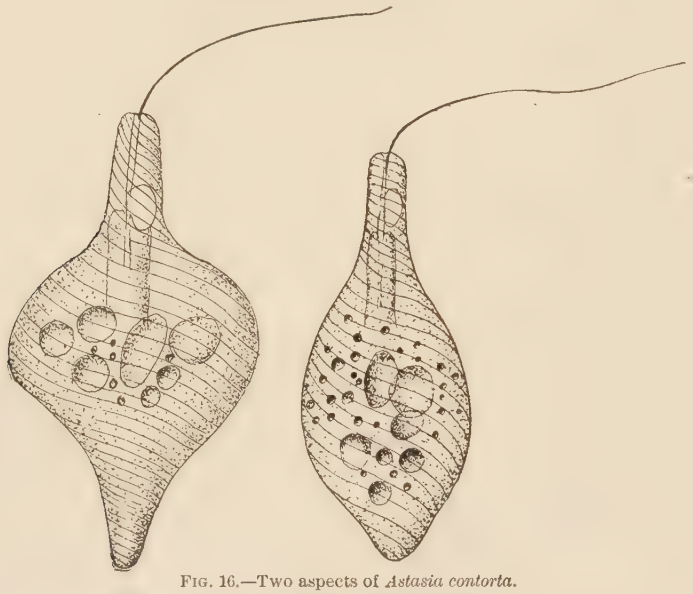


FIG. 16.—Two aspects of *Astasia contorta*.

Genus ANISONEMA Bütschli.

Flagellates with two flagella, of which one is directed forwards and is concerned with the locomotion of the animal, while the other is directed backwards and drags after the animal when in motion. Body slightly compressed dorso-ventrally (fig. 17, section). An oral furrow is present on the ventral side and the two flagella originate in it (fig. 17, at left). The vacuole is on the left side. Food vacuoles are present in the posterior part. The nucleus is central. Movement creeping.

Fresh and salt water.

FIG. 17.—*Anisonema vitrea*.

Anisonema vitrea (Duj.). Fig. 17.

Synonyms: *Tropidoscyphus octocostatus* Stein '83; *Sphenomonas* Kent '81; *Plœotia vitrea* Senn 1900.

With the characteristics of the genus. It differs from fresh-water forms in having eight furrowed surfaces running somewhat spirally from the posterior to the oral end. Length 50μ; width 23μ. This attractive flagellate was quite common in decaying algæ at Woods Hole; its shaking movement,

its peculiar furrowed surfaces, and, above all, its perfectly transparent, vitreous appearance, were well described by Dujardin. Stein's *Tropidoscyphus octocostatus* is a fresh-water form which may possibly be a distinct species, especially as it is described with both flagella directed forwards.

Genus DISTEPHANUS Stöhr.

An aberrant flagellate bearing a single flagellum and a silicious skeleton resembling those of the Radiolaria. The skeleton consists of two rings of different diameter parallel with one another and connected by silicious bars. From the wider ring half a dozen bars radiate outwards and a similar number of short thorn-like bars point inwards obliquely. The color is yellow, and except for the flagellum the form might easily be mistaken for a Radiolarian, as has been the case repeatedly.

Distephanus speculum Stöhr.

Dictyocha speculum Stöhr; *Dictyocha* Auc.

With the characters of the genus.

A single specimen only of this very interesting form was seen at Woods Hole. It occurred in a collection of tow made near the end of the wharf during the evening.

Key to families of Dinoflagellidia.

1. No cross-furrow; two free flagella ..... Family *Prorocentridæ*
2. One or more cross-furrows 3
3. Cross-furrow nearly central (cf. *Oxytoxum*) ..... Family *Peridinidæ*
   Cross-furrow close to anterior end ..... Family *Dinophysidæ*
   Several cross-furrows and flagella ..... Family *Polydinidæ*

(One genus, *Polykrikos.*)

Key to marine genera of Prorocentridæ.

Diagnostic characters: The transverse furrow is absent and the two flagella arise from the anterior end of the body. The shell may be bivalved.

1. No tooth-like process dorsal to the flagellum ..... Genus * *Exuviella*, p. 428
2. With tooth-like process dorsal to the flagellum ..... Genus *Prorocentrum*

Key to marine genera of Peridinidæ.

Diagnostic characters: The cross-furrow is nearly central (see, however, *Oxytoxum*); the body may or may not have a shell; the shell may or may not be composed of distinct plates; the plates are distinguished as *equatorial* (*i. e.*, bordering the cross-furrow), *apical*, and *antapical*, while still another, the "rhombic plate," may be present, extending from the cross-furrow to the apex.

1. Without distinct shell ..... Genus * *Gymnodinium*, p. 429
   With a distinct shell 2
2. Shell not composed of definite plates 3
   Shell composed of definite plates 4
3. Cross-furrow replaced by thin-skinned band ..... Genus *Ptychodiscus*
   Cross-furrow well defined; reticulate markings raised on shell-surface ..... Genus *Protoceratium*
   Cross-furrow well defined; no markings ..... Genus * *Glenodinium*, p. 429
4. Two parts of shell equal or nearly equal 5
   Two parts of shell very unequal 11
5. With transverse flagellum in a distinct furrow 6
   Transverse flagellum not in a furrow 10
6. With horns, or with wing-like processes 7
   Without processes of any kind 9
7. Processes small, wing-like, around flagellum-fissure ..... Genus *Diplopsalis*
   Processes horn-like 8
8. Anterior part with 7 equatorial and 1 rhombic plates ..... Genus * *Peridinium*, p. 430
   Anterior part with 5 equatorial and no rhombic plates ..... Genus *Gonyaulax*
   Anterior part with 3 equatorial and no rhombic plates ..... Genus * *Ceratium*, p. 431
9. Anterior part with 14 equatorial and 1 rhombic plates ..... Genus *Pyrophacus*
   Anterior part with 7 equatorial plates ..... Genus *Goniodoma*
   Anterior part with 4 equatorial plates ..... Genus *Amphidoma*
10. Apical extremity drawn out into a tube ..... Genus *Podolampas*
    Apical extremity not drawn out into a tube ..... Genus *Blepharocysta*
11. Cross-furrow deep, with great ledge-like walls ..... Genus *Ceratocorys*
    Cross-furrow wide, no ledge-like walls ..... Genus *Oxytoxum*

Key to marine genera of Dinophysidæ.

Diagnostic characters: The cross-furrow is above the center of the body, and its edges, as well as the left edge of the longitudinal furrow, are usually produced into characteristic ledges; those of the cross-furrow usually form great funnel-like anterior processes, while those of the longitudinal furrow usually form great, lateral, wing-like processes ornamented by ribs and other markings.

1. Without shell; longitudinal furrow may open and close ..... Genus **Amphidinium*, p. 432
2. With shell; longitudinal furrow unchangeable 3
3. With distinct apical funnel 4
   No apical funnel ..... Genus *Phalacroma*
4. With great wing-like ledge 5
   Ledges very small; body long, needle-like ..... Genus *Amphisolenia*
5. Ledge of longitudinal furrow extends to posterior end 6
   Ledge of longitudinal furrow does not extend to posterior end ..... Genus *Dinophysis*
   (Recorded by Peck ('93–'95) as very abundant at Woods Hole and in Buzzards Bay.)
6. Ledge is continued dorsally to the cross-furrow ..... Genus *Ornithocercus*
   Ledge is not continued dorsally 7
7. With deep dorsal cavity; secondary funnel not notched ..... Genus *Citharistes*
   No dorsal cavity; secondary funnel deeply notched ..... Genus *Histioneis*

FIG. 18.—*Exuviælla lima.*

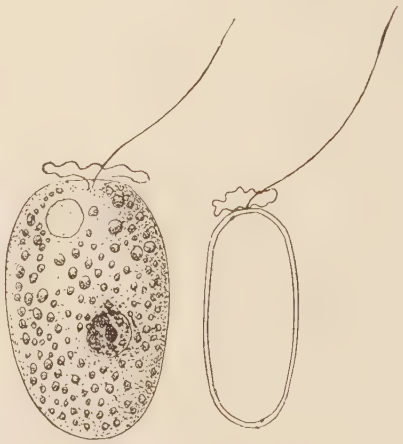


FIG. 19.—*Exuviælla marina.*

Genus EXUVIÆLLA Cienkowsky '82.

(Klebs '81; Pouchet '83, '85.)

The form varies from globular to ovoid, with occasionally a sharp posterior end. Shells are usually somewhat compressed, and consist of two valves, which frequently slide one over the other in such a manner as to show the structure with great clearness. The right shell may have a distinct indentation in the anterior edge. There are two lateral, discoid, brown chromatophores, each of which possesses a central amylum granule. The nucleus is posterior. Salt water.

Exuviælla lima Ehr. Fig. 18.

Synonyms *Pyxidicula* Ehr.; *Cryptomonas* Ehr.; *Prorocentrum lima* Kent; *Amphidinium* Pouchet.

The shell is ovate, rounded and swollen posteriorly. The anterior border of both shells is slightly indented. The shell is quite thick. The animal moves through the water very slowly. Dark brown in color. Length 48μ; width 44μ.

Exuviælla marina Cienkowsky. Fig. 19.

A smaller form than the preceding, more elliptical in outline, with a thinner shell and with large granules throughout the endoplasm. The nucleus is spherical and subcentral in position and possesses a distinct central granule. This may be a small variety of *E. lima*.

Genus GYMNODINIUM Stein '78.

(Bergh '81; Kent '81; Pouchet '83, '85; Entz '84; Schütt '95.)

The general structure of these forms is similar to that of *Glenodinium;* the most striking and positive difference is the absence of a shell. The animals are, as a rule, spherical, yet they may be pointed at the two ends or at one of them. They are also frequently flattened dorso-ventrally. The transverse furrow may be either circular and straight around the body or may describe a spiral course, passing even twice around the body. The flagella arise near cross-furrow or, in some cases, in longitudinal furrow. Chromatophores may or may not be present and food-taking is holozoic, in many cases at least. In some cases ectoplasm and endoplasm can be distinguished. Fresh and salt water.

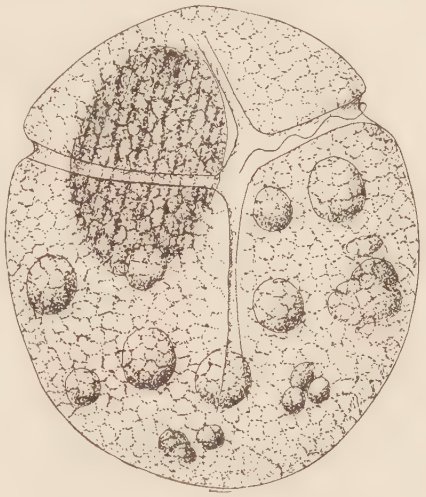


FIG. 20.—*Gymnodinium gracile*, var. *sphærica*.

Gymnodinium gracile Bergh '82, var. **sphærica**, n.

The body is divided by the transverse furrow into a shorter anterior and a longer posterior part. The longitudinal furrow is broader at the posterior extremity than at the cross-furrow. The structural feature upon which this new variety is made is the unvarying plumpness of the body, making it almost spherical, except for a slight flattening dorso-ventrally. The nucleus is large and ellipsoidal, with characteristic longitudinal markings of chromatin. The endoplasm is evenly granular, with a number of large ingested food bodies. The color is brown, not rose-red as in Bergh's species, nor is the Woods Hole form as large as the latter.

Length of body 68μ; width 55μ. Common.

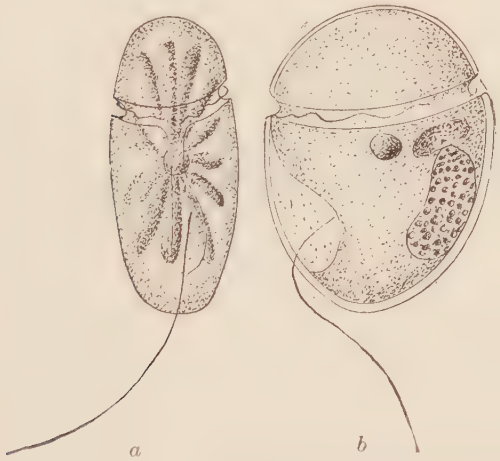


FIG. 21 *a, b, c.*—*Glenodinium compressa*, n. sp.

FIG. 22.—*Glenodinium cinctum*.

Genus GLENODINIUM (Ehr.), Stein '83.

(Bergh '82; Bütschli '86; Pouchet '85; Daday '86.)

Small globular forms with two distinct furrows, one transverse around the body, the other longitudinal upon the face only. The shell is soft and structureless with a distinct aperture near the meeting-point of the two furrows. The endoplasm usually, but not always, contains a bright red "eye-spot."

Fresh and salt water.

Glenodinium compressa, n. sp. Fig. 21, *a*, *b*, *c*.

This species resembles *G. acuminata* of Ehrenberg except that it is strongly compressed laterally. The longitudinal furrow extends nearly to the extremity of the animal. It begins as a narrow slit and widens as it progresses upon the left side; it also becomes much deeper on this side and at the bottom of the depression the longitudinal flagellum is inserted. The transverse furrow runs evenly around the body near the upper pole, giving to the shell almost the aspect of an *Amphidinium*. Brown chromatophores may or may not be arranged radially about a central amylum granule. One striking characteristic is the depth of the two furrows. The nucleus is elongate and somewhat curved; it lies against the posterior wall of the rather thick shell. Not uncommon.

Length 40μ; breadth 32μ; width 18μ.

The posterior end of the animal is often somewhat pointed and this point frequently becomes attached, so that the animal whirls around upon it as upon a pivot.

Glenodinium cinctum Ehr. Fig. 22.

The body is globular, smooth, and homogeneous. Brown chromatophores arranged radially, each in the form of a cone, the base of which rests against the shell while the points turn inward. A bright-red eye-spot may or may not be present; when present it is placed near the junction of the two furrows. The longitudinal furrow is small. Fresh water and salt.

Length and diameter the same, 21μ.

This species was observed by Peck '93.

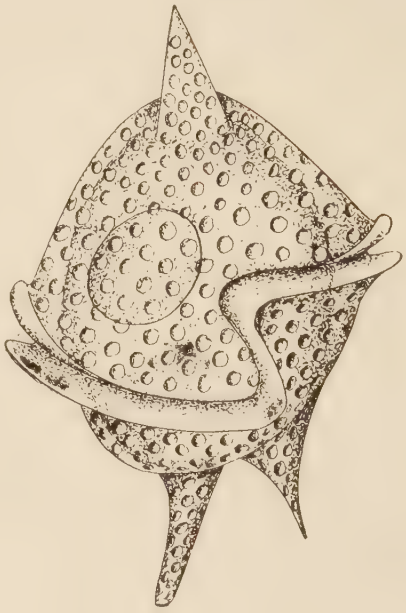


FIG. 23.—*Peridinium digitale.*

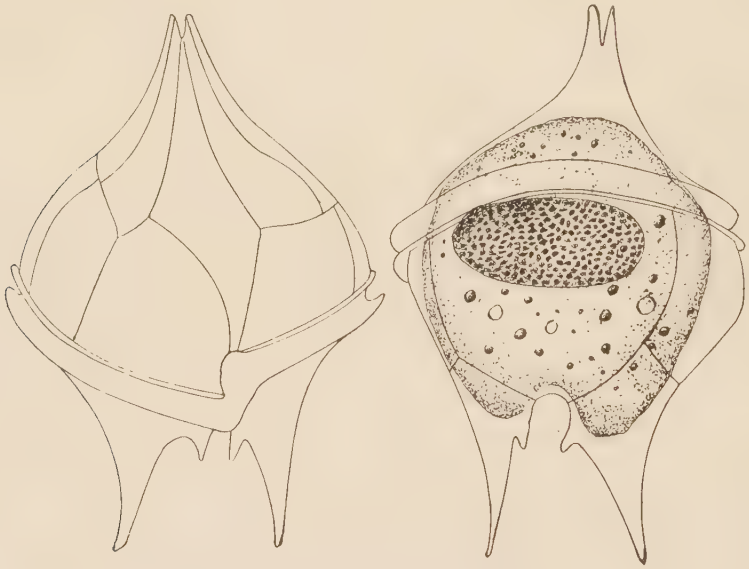


FIG. 24.—Ventral and dorsal aspects of *Peridinium divergens.*

Genus PERIDINIUM Ehr. '32, Stein '83.

(Claparède & Lachmann '58; Bergh '81; Pouchet '83; '85; Gourret '88; Bütschli '86.)

The form is globular, ovoid or elongate, the apex frequently drawn out into a long tube. The transverse and longitudinal furrows are quite distinct, the former having often a spiral course about

the body. The two halves of the body are similar, the posterior being somewhat shorter; the anterior half has seven equatorial plates, an oral plate, two lateral apical plates, and one or two dorsal plates. The two antapical plates frequently have a tooth-like process. The bodies are colorless, green or brown.

Fresh and salt water.

Peridinium digitale Pouchet. Fig. 23.

Synonyms: *Protoperidinium digitale* Pouchet; *Protoperidinium* Bergh p. p.; *P. divergens* Peck.

The shell is covered with pits of large size. The posterior part is hemispherical and surmounted by a single horn or spine. The transverse furrow is very oblique, and its two extremities are united by a sigmoid longitudinal furrow. The anterior half bears two spines or horns of different size, and variable. The nucleus is spherical or ellipsoidal and placed in the posterior half of the shell.

Length 68μ; diameter 54μ. Common.

Although the description of Pouchet's *P. digitale* differs in some respects from a careful description of the Woods Hole form, I think the species are the same. The chief difference is in the single horn of the posterior half; in Pouchet's form this is furrowed by a narrow groove which runs to the S-shaped longitudinal furrow. In the Woods Hole form I was unable to make out such a furrow. The flagella, also, were not seen. This same form was pictured by Peck '95 as *P. divergens*.

Peridinium divergens Ehr. Fig. 24.

Synonym: *Ceratium divergens* Kent.

The shell is spheroidal, widest centrally, attenuate and pointed posteriorly; the anterior portion is armed with two short, pointed horns, each of them having a toothed process at the basal portion of the inner margin. They are frequently colorless and beautifully transparent, the body being free from large opaque granules; again they are colored brown or yellow. The nucleus is large and elongate and finely granular. 75μ long and 68μ in diameter. Common.

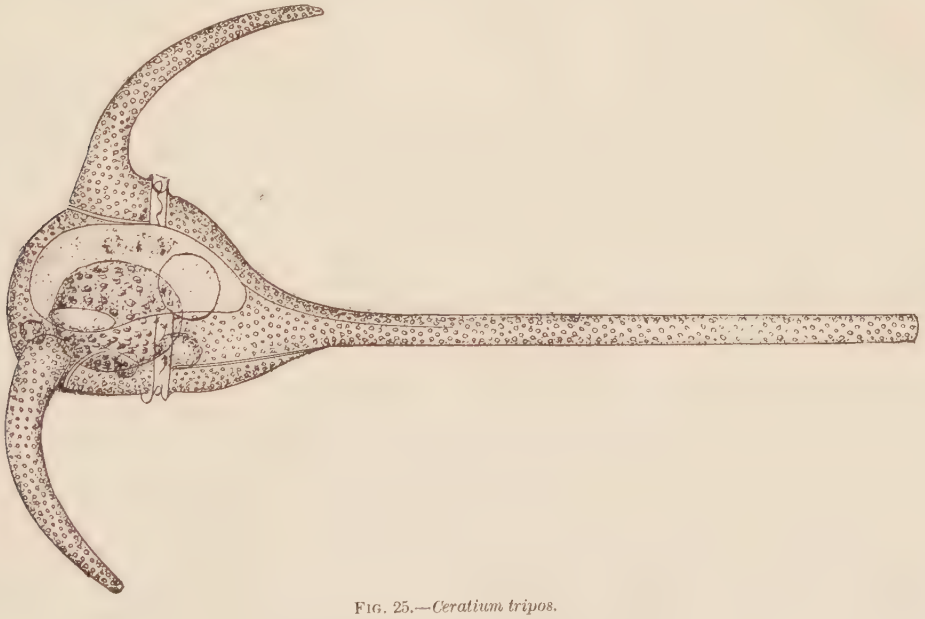


FIG. 25.—*Ceratium tripos.*

Genus CERATIUM (Schrank).

(Stein '78; Perty '52; Clap. & Lach. '58; Bergh '82; Pouchet '83; Gourret & Roeser '88; Bütschli '85; Kent '81; Senn 1900; Schütt '98.)

The general shape is a flattened sphere with three long processes or horns. The cross-furrow is either spiral or circular; the longitudinal furrow is usually wide and occupies the greater part of the

anterior half of the shell. The shell is thick, reticulate or striped, and sometimes provided with short spines; often distinctly porous. The anterior half is composed of 3 equatorial and 3 apical plates, the latter being continued into the horn-like process. The posterior half is composed of 3 equatorial and one apical plate continued into the posterior horn. The right posterior plate is continued into a similar horn which may remain rudimentary or be continued into a considerable process. Similarly the left posterior horn is usually developed, but remains small. There may be from 2 to 3, 4, and 5 horns. Chromatophores usually present, green to yellow brown.

Fresh and salt water.

Ceratium tripos Ehr. Fig. 25.

The body is somewhat triangular and bears three horns, two of which are shorter than the other one and slightly curved upward.

Length, including the horns, 290μ.

FIG. 26.—*Ceratium fusus.*

Ceratium fusus Ehr. Fig. 26.

Synonym: *Peridinium fusus* Ehr.

The animal is very elongate, due to the presence of two long horns at the extremities of the body. Color, yellow with chromatophores. Length 285μ; width 23μ.

Both of these species are common in the tow and in the algæ at the edge of the wharf. Both of them are mentioned by Peck in '93 and '95.

Genus AMPHIDINIUM Clap. & Lach.

The body is ovoid to globular and usually much flattened dorso-ventrally. The anterior portion is very much reduced and is somewhat head-like or cap-like. The longitudinal furrow extends through the entire posterior body length and is apparently capable of widening and narrowing. It is probably naked (see here Klebs, Pouchet, Bütschli), although Stein maintained that there is a delicate cuticle-like shell. Chromatophores of brown or green colors present and usually grouped radially about a central amylum granule. The nucleus is posterior.

Fresh and salt water.

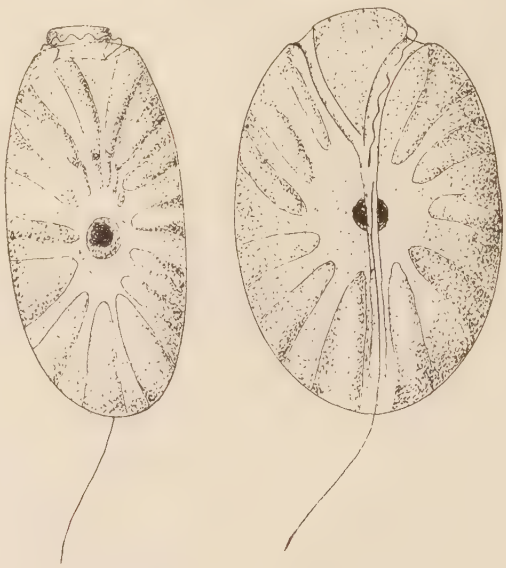


FIG. 27.—*Amphidinium operculatum.*

Amphidinium operculatum Clap. & Lach.

The body is oval and flattened. The transverse furrow is at the extremity (posterior) of the body and the small portion, which is thus apparently cut off, is the cap-like or operculum-like structure which gives the name to the species. Klebs maintains that the two furrows are not connected, but in this he is certainly mistaken, provided we have the same species under consideration. Very common about Woods Hole.

Length from 40 to 50μ; width 30μ; thickness 15μ.

Key to Infusoria.

1. With cilia ..... Subclass *Ciliata*. 3
2. Without cilia (in adult state) tentacles ..... Subclass *Suctoria*
3. *a.* Without a specialized fringe of large cilia (ad. zone) ..... Order *Holotrichida*
   b. With general covering of cilia + adoral zone ..... Order *Heterotrichida*
   c. With cilia on ventral side + adoral zone ..... Order *Hypotrichida*
   d. With cilia in region of adoral zone, and about mouth only ..... Order *Peritrichida*

Key to families of the Holotrichida.

A. Mouth closed except during food ingestion; no undulating membrane 1
   Mouth always open; with undulating membrane 2
   1. *Gymnostomina.*
      a. Mouth terminal or subterminal. Food is swallowed and not introduced by currents ..... Family *Enchelinidæ*
      b. Mouth terminal or subterminal; body frequently drawn out into long process; mouth may have specialized framework ..... Family *Trachelinidæ*
      c. Mouth central or posterior; pharynx with supporting framework ..... Family *Chlamydodontidæ*
   2. *Trichostomina.*
      a. Mouth anterior or central; pharynx short or absent; peristomial depression faint or absent ... Family *Chiliferidæ*
      b. Mouth central; pharynx long, tubular; cilia in two broad zones ..... Family *Urocentridæ*
      c. Mouth posterior; form asymmetrical; cilia dispersed or limited to oral region ..... Family *Microthoracidæ*
      d. Mouth anterior or central. Peristomial depression clearly marked. (One genus, *Paramæcium*.) .... *Paramæcidæ*
      e. Mouth at end of long peristome running along ventral side; body dorso-ventrally or laterally compressed; left edge of peristome with great, sail-like undulating membrane ..... Family *Pleuronemidæ*
      f. Mouth and pharynx distinct, posterior; cilia uniform. Parasites in ruminants ..... Family *Isotrichidæ*
      g. Mouth absent; body vermiform, cilia uniform. Usually parasites ..... Family *Opalinidæ*

Key to marine genera of Enchelinidæ.

Diagnostic characters: Form ellipsoid or ovoid; the mouth is invariably terminal and is usually round—more rarely slit-formed; it is closed except when food is taken. An œsophagus when present is a short, invariably non-ciliated tube which is usually surrounded by a more or less clearly defined buccal armature. The anus is usually terminal. Large food particles are swallowed, never introduced by currents.

1. Body naked 3
2. Body inclosed in a shell or coat 7
3. *a.* Cilia uniform about the entire body; body symmetrical 4
   b. Cilia in the mouth region longer than the others; body symmetrical 5
   c. Bristles, or tentacles, in addition to cilia 6
4. Mouth terminal; body ellipsoidal to ovoid ..... Genus *Holophrya*
5. *a.* Mouth terminal; body elongate, flexible, and elastic ..... Genus *Chænia*
   b. Mouth terminal; "neck" highly elastic; entire body flexible; conical "head" ..... Genus * *Lacrymaria*, p. 433
   c. Mouth terminal; "neck" highly elastic; entire body flexible; "head" square ..... Genus * *Trachelocerca*, p. 435
   d. Mouth terminal; "neck" highly elastic; no separate mouth-bearing portion ..... Genus *Lagynus*
6. *a.* Body asymmetrical; bristles in addition to cilia ..... Genus *Stephanopogon*
   b. Body symmetrical; 4 small tentacles from mouth; cilia and cirri in girdles ..... Genus * *Mesodinium*, p. 435
7. Shell composed of small sculptured pieces; cilia long, uniform ..... Genus * *Tiarina*, p. 436

Genus LACRYMARIA Ehr. '30.

(Ehrenberg, C. G., 1838; Perty '52; Claparède & Lachmann '58; Stein 59–83; Quennerstedt '65, '67; Fromentel '74; Kent '81; Gruber '84; Gourret & Roeser '86; Bütschli '88; Schewiakoff '89.)

Body short to very long flask-shape; for the most part contractile, especially in the neck region. The posterior end is rounded or pointed. The main character is the mouth-bearing apex, which "sets like a cork in the neck of the flask." One or more circles of long cilia at the base of the mouth portion or upon it. The body is spirally striped. Contractile vacuole terminal, with sometimes one or two further forward. Macronucleus central, globular to elongate, sometimes double. Food mainly bacteria. Fresh and salt water.

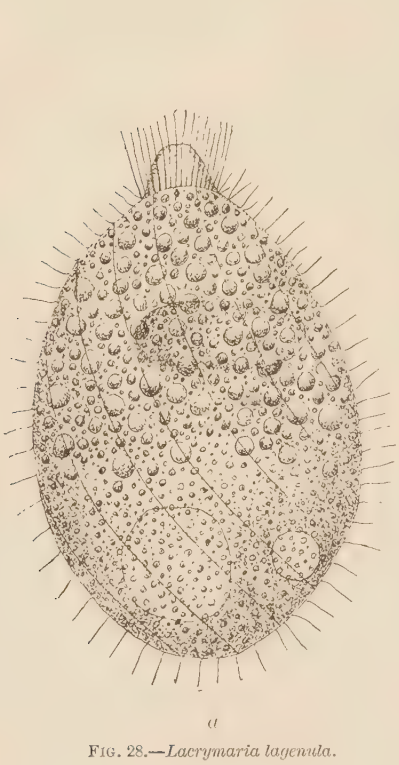
Lacrymaria lagenula Clap. & Lach. Fig. 28, *a*, *b*.

Synonym: *L. tenuicula* Fromentel '74.

Body more or less flask-shape, two or three times as long as broad, with conical apex, which is slightly elastic and protrusible; surface obliquely striate, with well-defined lines, 14 to 16 in number; cilia uniform on the body, with a crown of longer ones at the base of the conical proboscis. The

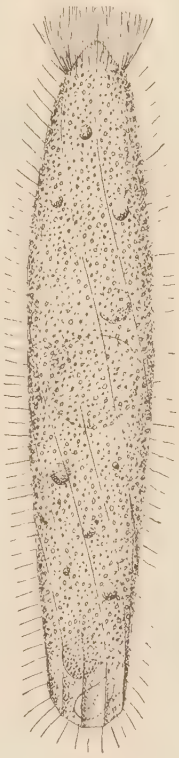
body cilia are not thickly placed except around the proboscis. The endoplasm is thickly packed with large granules (food particles) in the anterior half and with finely granular particles in the posterior half. The elongate macronucleus lies a little above the center among the larger granules; the contractile vacuole is double, one on each side of the median line and at the posterior end of the body among the finer granules. The anus is posterior. Length 90μ to 160μ; greatest width assumed 65μ. When fully expanded the posterior end assumes a curious polyhedral form. (Fig. 28 *b*.)

This form differs slightly from others of the same species as described by different observers, the most striking difference being the presence of two contractile vacuoles in place of the usual one. These are very slow to fill and grow to a large size before diastole. The membrane is very tough and retains its form easily under pressure of the cover glass. Another characteristic feature is the flattening of the surfaces between the striæ. Decaying algæ.



a

FIG. 28.—*Lacrymaria lagenula.*



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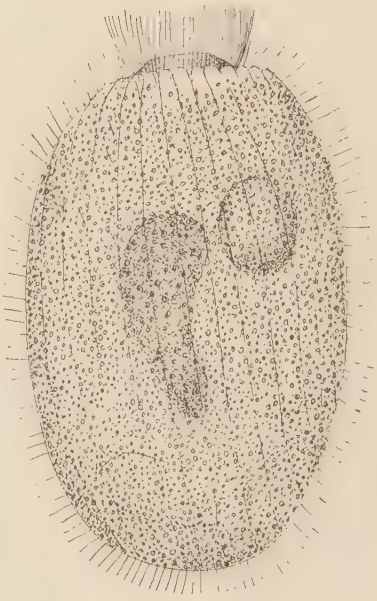


FIG. 29.—*Lacrymaria coronata.*

Lacrymaria coronata Cl. & Lach. '58. Fig. 29.

Synonyms: *L. lagenula* Cohn '66; Möbius '88; *L. cohnii?* Kent '81; *L. versatilis* Quen. '67.

Form flask-like and similar to *L. lagenula*, contractile but tough. The contractile vacuole is terminal, the proboscis is short, slightly raised and separated from the body by a deep cleft; the buccal cilia are inserted part way up on the proboscis. Form changeable, from short, sac-like to elongate and vermiform. Length 85μ.

This species is not very different from *L. lagenula*, but I noted that in addition to the elongate nucleus, the body striæ are much more apparent here and seem to sink into the cuticle, giving the periphery, especially at the collar region, a curious crenulated effect. The endoplasm is very densely granular and colored a blue-green, probably from food particles. The number of striæ is much larger than in the preceding species. The membrane is very tough and retains the shape of the body, even with the full pressure of the cover glass. Micronucleus and trichocysts were not observed.

Genus TRACHELOCERCA (Ehr. '83) Cohn '66.

(Quennerstedt '67; Gruber '87; Entz '84; Kent '81; Gourret & Roeser '88; Bütschli '88; Schewiakoff '89; Shevyakov '96.)

The only well-known representative is very elongate, large (up to 3 mm. Van Beneden), and very contractile. The main feature of importance in distinguishing it is the 4-part structure of the mouth region, which, however, may not be obvious. Pharynx faint and smooth. Contractile vacuole terminal. Macronucleus in one central body or in numerous pieces scattered throughout the cell. Salt water.

Trachelocerca phœnicopterus Cohn '66. Fig. 30.

Synonyms: *T. sagitta* Ehr. '40, Stein '59; *T. tenuicollis* Quennerstedt '67, Kent '81; *T. minor* Gruber '87, Shevyakov '96.

The body is extremely elongate and ribbon-like, and this, combined with its wonderful power of extension and retraction, makes it one of the most curious and interesting of microscopic forms. The anterior end is square or cylindrical; the type species has a four-sided mouth, but many specimens may be found which have a plain cylindrical mouth region. One reason for this may be the fact that the extremity gets broken off. In one instance I noticed a very large form with the anterior end under some débris, which evidently held it tight, for the body of the ciliate was thrashing back and forth and twisting itself into knots, etc., like a nematode worm. Finally, the anterior end broke off with about one-tenth of the body; the remainder, in an hour, had regenerated a new anterior end with long cilia, but with no indication of four sides. The small anterior piece was also very lively,

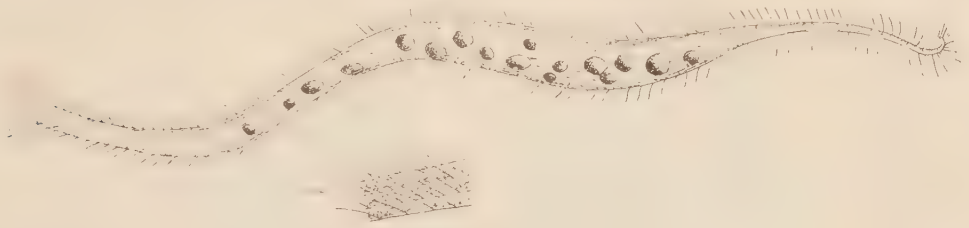


FIG. 30.—*Trachelocerca phœnicopterus.*

moving about and eating like the normal animal; its history, however, was not followed. This species appears to be variable in other ways as well; thus, in some cases the posterior end is rounded (cf. Entz '84); in others it is pointed (cf. Kent '81, Cohn '66, et al.).

Again, the macronucleus may be a single round body (Entz '84, Bütschli '88) or in two parts (Kent '81), or in many parts scattered about the body (Gruber). In the Woods Hole forms the tail is distinctly pointed and turned back sharply, forming an angle at the extremity. The cilia on this angular part are distinctly longer than the rest. The function of this posterior part is apparently to anchor the animal while it darts here and there upon the tail as a pivot, contracting and expanding the while. The body is finely striated with longitudinal markings; when contracted there are no transverse markings nor annulations. The nucleus is in the form of many fragments scattered throughout. Length of large specimen 1.7 mm.

Genus MESODINIUM Stein '62.

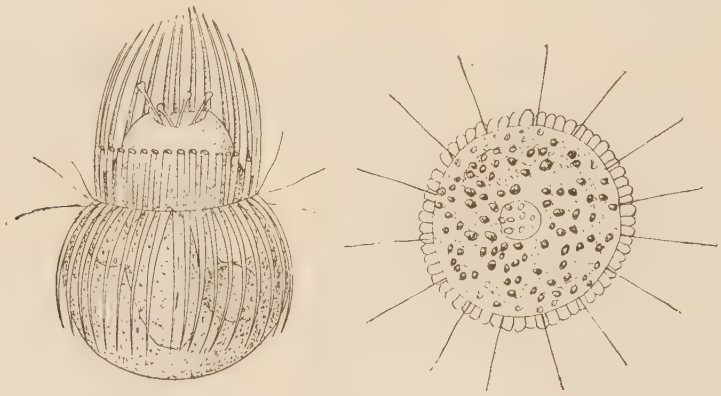
(Maupas '82, '84; Entz '84; Shevyakov '96.)

The main part of the body is globular or conical, with a short, platform-like oral region, and a deep annular groove about the middle of the body. The œsophagus is rather long, and smooth or longitudinally striped. One or more rings of cirri rise in the groove. If more than one ring of cirri are present, the anterior set usually point forward and lie close to the anterior part of the body. The posterior set, on the other hand, cling close to the posterior region of the body and give to it a peculiar encapsuled appearance. The most characteristic feature is the presence of four short tentacle-like processes which can be protracted and retracted from the oral region. (Mereschowsky says that the entire anterior half is more or less contractile.) The macronucleus is horseshoe-shaped or ovoid and is situated in the posterior half of the body. The contractile vacuole is also posterior.

Movement consists in rapid swimming, with rotation on its axis, or in creeping by means of its anterior cirri, or in sudden jumping, by which it apparently clears a distance of 20 times its diameter in one bound. Mouth parts may also be used for attachment to foreign bodies. The moving periods alternate with quiescent periods, during which the organisms with their outstretched and radiating cirri resemble the heliozoön *Actinophrys*.

Mesodinium cinctum, n. sp. Fig. 31.

Body spherical to pyriform, constricted near the middle, the constriction dividing the body into dissimilar parts. The anterior part is broadly pyriform, somewhat plastic and hyaline, with an oral extremity which is sometimes hollow, sometimes evaginated and convex. Upon this flexible anterior part there are four short but distensible tentacles. The posterior part is granular and usually filled with food particles; it is well rounded and holds the nucleus and contractile vacuole. The entire body is surrounded by a fine cuticle. The nucleus is elongate and extends through the greater part of the posterior half. The contractile vacuole lies on one side, near the girdle. The mouth is on the anterior pole in the tentacle region. The motile organs are cirri and cilia, all inserted in the constriction. There are two sets of cirri and one of cilia; the latter stand out radially from the girdle and are usually in motion. The cirri of one set, the anterior, extend forward about twice the length of the anterior half; those of the posterior set closely engirdle the lower half, reaching not quite to the posterior extremity. These are somewhat hyaline and are closely approximated, giving the impression of a tight-fitting crenulate casing about the lower half. The cirri are sharply pointed, much broader at



a *b*

FIG. 31.—Side and top views of *Mesodinium cinctum*.

the base, and the two sets are so placed that, looked at from above, they have the appearance of a twisted cord. (Fig. 31 *b*.) Movement erratic; sometimes the animal swims steadily forward with mouth in front; again it shoots across the field of the microscope, either backward or forward or sideways, through the action of its powerful cirri. It is often quiet, usually mouth downward, and is held in place by adhesion of the tentacles. In this position it looks strikingly like a heliozoön.

Length 35μ; greatest width 30μ. Not uncommon.

The chief features by which this species is distinguished from the frequently described *M. pulex* of Europe are the number of anterior cirri and the ring of true cilia in place of the central girdle of cirri. The European form is described with four anterior bristles; the present form has from 28 to 32. The radial cilia differ decidedly from the more powerful cirri and they are not in one plane, so that counting is difficult; they are not closely set. The presence of tentacles makes these forms of especial theoretical interest, especially in the light of the origin of *Suctoria*.

Genus TIARINA R. S. Bergh '79.

(Claparède & Lachmann '58.)

Body subcylindrical, pointed posteriorly, two and one-half times as long as broad; encased in covering composed of separate pieces arranged in five girdles. The pieces bear processes which rest against neighboring pieces of the girdle. Mouth large, anus terminal near contractile vacuole. The macronucleus is simple and round. Salt water.

Tiarina fusus (Cl. & Lach.) emend R. S. Bergh.

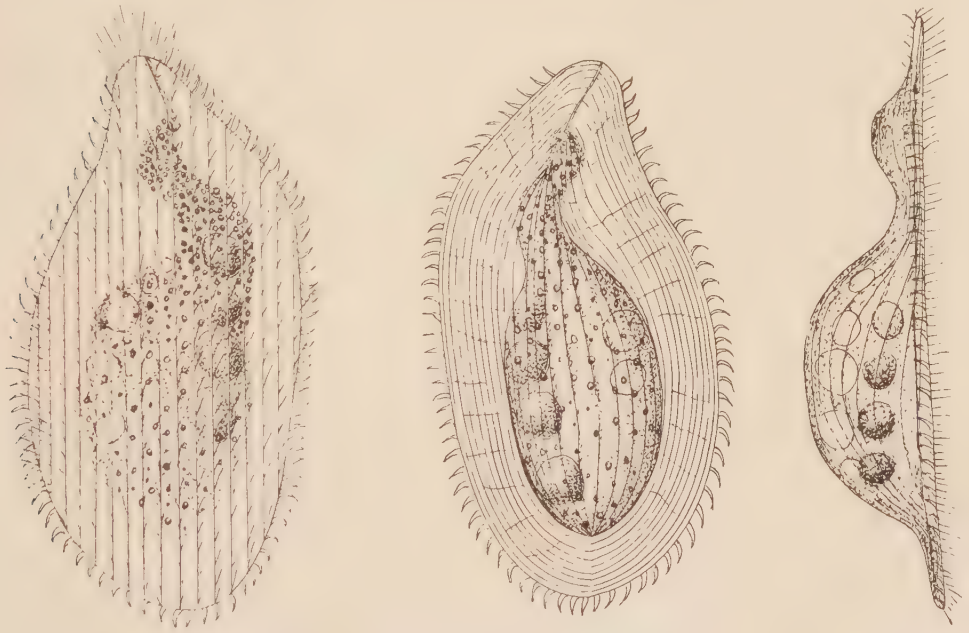
Synonyms: *Coleps fusus* Cl. & Lach. '58; Daday '86; Möbius '88, Lauterborn '94; Shevyakov '86.

This form, which resembles *Coleps* rather closely, was placed as a separate genus by R. S. Bergh. The skeletal parts consist of five zones of needles composed of an organized substance and embedded in the cortical plasm, the last zone coming to a point at the posterior end. The needles have lateral processes, which give a latticed appearance to the casing. The cilia are long, with a specialized crown of still longer ones at the oral end; they arise outside of the skeletal elements and do not pass between them, as in *Coleps*.

Key to marine genera of Trachelinidæ.

Diagnostic characters: Body bilateral, or asymmetrical by local prolongations; usually compressed or flattened laterally, the left side more convex than the right. The essential feature is the position and character of the mouth. This is either a long slit extending from the anterior end well down the ventral surface, or the posterior part only of a ventral furrow remains open as a round or elongate mouth some distance from the anterior end. The entire mouth region of the body is usually drawn out into an elongate tapering proboscis which is generally curved dorsally at the extremity. An œsophagus is short or absent altogether; when present it is supported by a stiff buccal armature. Cilia are uniform about entire body or limited to the flat right side. Food is swallowed.

1. *a.* Proboscis easily distinguished from the main body 2
   b. Proboscis not marked off from main body; body flat; both surfaces striated.....Genus * *Loxophyllum*, p. 437
2. *a.* Mouth runs the entire length of proboscis; entire body uniformly ciliated. .....Genus *Amphileptus*
   b. Mouth runs the entire length of proboscis; body flat; right side only is ciliated .....Genus * *Lionotus*, p. 438
   c. Proboscis much drawn out, flexible; mouth at its base.....Genus *Dileptus*



a *b* *c*

FIG. 32.—*Loxophyllum setigerum*, var. *armatum*. *a*, *b*, *c*, ventral, dorsal, and lateral aspects

Genus LOXOPHYLLUM Duj. '41.

(Duj. '41; Wrzesniowski '69; Quennerstedt '65; '67, Cohn '66; Entz '84; Gourret & Roeser '88; Bütschli '88; Shevyakov '96.)

The body is flat and somewhat leaf-shape, flexible, and elastic. The anterior end is somewhat proboscis-like and flexible, but is not sharply demarcated as in *Lionotus*. The central portion of the body is developed into a more or less arched dorsal mass, which usually contains the nuclei and contractile vacuoles. As a result of this local thickening, the body is surrounded by a thin hyaline margin. This, however, may be absent on the right side in some species. The mouth reaches from the anterior

extremity to a short distance from the end, and usually approaches the left edge. An anus is present near the posterior end of the dorsal swelling. Trichocysts are numerous on the ventral surface, and often on the dorsal surface, where they are inclosed in minute papilla-like swellings. Cilia-distribution controverted. Maupas and Bütschli hold that ventral surface alone is ciliated; others (Kent and Dujardin) that cilia are uniformly distributed. The entire body, dorsal and ventral surfaces alike, are uniformly striated. The contractile vacuole lies posteriorly, on the right side and in the dorsal swelling. In the fresh-water form *L. meleagris*, it is connected with a long canal whose swellings are frequently taken for additional contractile vesicles (Bütschli); in the marine form described below the canal is not developed and a series of vacuoles takes its place; these are all contractile. The macronucleus may be single, double, quadruple, band-formed, or rosette-formed. Movement is steadily progressive and peculiarly gliding. Fresh and salt water.

Loxophyllum setigerum Quenn. '67.

Synonyms: *Litosolenus armatus* Stokes '93; *Litosolenus verrucosa* Stokes '93.

The body is flattened, irregular in outline, obtusely pointed anteriorly, the point being turned to the right; rounded posteriorly. The left edge is nearly straight, the right considerably arched with a few setæ on the posterior half. Contractile vacuoles are numerous, dorsal in position and on the right side. The macronucleus is beaded, the several spheres connected.

Variety **armatum** (Cl. & Lach.). (Fig. 32.)

Under the name *Litosolenus armatus*, Stokes described a form from brackish water near New York, which should unquestionably be referred to the genus *Loxophyllum*, and I believe to Quennerstedt's species *setigerum*. While the latter possesses only a few setæ, the former has a number of them, and Stokes described his species as having a variable number. For this reason I include the Woods Hole form under the tentative name *armatum*, as a variety of Quennerstedt's *L. setigerum*. The flat margins are distinctly striated longitudinally, and faintly marked radially, on the dorsal surface. Longitudinal elevated striæ also run the length of the dorsal hump and upon the entire ventral surface. The ventral surface is alone ciliated. Upon the edges of the flat border are sharp-pointed, colorless, spine-like processes, situated at equal distances around the entire periphery except at the anterior end. Each spine is thick at the base and tapers to a full point which is curved upward—*i. e.*, dorsally (fig. 32, *a*, *b*). The entire body is plastic and contractile, turning its leaf-like edge readily over objects upon which it creeps. The cilia are fine and uniform, with a tendency to lengthen in the oral region.

Length 100μ; greatest width assumed on contraction 85μ; when normal about 50μ.

Genus LIONOTUS Wrzesniowski '70.

(Incorrectly called *Litonotus* by many. Entz '84; Gruber '84; Bütschli '88; Kent '81; Schewiakoff '89; Shevyakov '96.)

The body is elongate and somewhat lance-shaped, widest at the central part and tapering to a point at the anterior end. The posterior end may be similarly tapered or rounded. The anterior end frequently proboscis-like, flat, and flexible, while the entire body is more or less elastic and contractile. The right side is flattened and alone provided with cilia, while the left side of the body proper is arched; on the left side of the proboscis is a row of coarse cilia resembling an adoral zone, and a row of trichocysts. A long peristome stretches down the thin, ventral side of the proboscis, and the mouth proper is situated at the junction of the proboscis and body; the mouth, as a rule, is invisible. The ciliated right side alone is striated in the majority of species. The contractile vacuole may be single or multiple, usually in the posterior region of the body and dorsal in position. The macronucleus is usually double, rarely single or quadruple, but may occasionally break into numerous smaller pieces. Movement, free-swimming or gliding, with especial tendency to get under clumps of foreign matter.

Fresh and salt water.

Lionotus fasciola Ehr. Fig. 33.

Synonyms. *Amphileptus fasciola* Ehr. '38; Dujardin '41; Lachmann '56; Cohn '66, Diesing '65.
Loxophyllum fasciola Claparède & Lachmann '58; Balbiani '61
Loxophyllum duplostriatum Maupas '83. Shevyakov '96

Body frequently brown or brilliant yellow in color, somewhat sigmoid in form with tapering anterior end, the extremity of which is turned dorsally. The proboscis is about half the entire length

and is not sharply marked from the rest of the body but tapers gradually, its base being equal to the diameter of the body at its middle point. The body is slightly contractile and the posterior end is carried to a rounded point, but not into a distinct tail. Unlike the fresh-water variety, this one has no hyaline margin nor hyaline caudal region, and the contractile vacuole is double or multiple on the dorsal side near the posterior end. Cilia are present only on the under (right) side, with, however, a row of large cilia marking the course of the elongate mouth, upon its left side. The right side is striated, the left arched and without markings. The endoplasm is finely granular with, however, larger food particles in the process of digestion, while specimens are occasionally seen with the natural form completely lost through distortion caused by over-large captures (Cf. also Wrzesniowski '70, p. XXIII, fig. 32). Movement continuous, slow, and gliding; very little tendency to jerking movements. Macronucleus double, both parts spherical, and placed in about the center of the larger part of the body; closely approximated but not, as Schewiakoff described, connected. In conjugation, a large form unites with a smaller one, the mouth parts being connected. Details of conjugation and macronuclei not made out. Length 200μ to 600μ.

FIG. 33.—*Lionotus fasciola.*

Key to marine genera of Chlamydodontidæ.

Diagnostic characters: Form usually ellipsoid, never very elongate. Transverse section of body circular or elliptical. The mouth is usually some distance from the anterior end and may be in the posterior part. Sometimes it is in the center of the ventral surface, again on the right side. The œsophagus invariably has a well-developed buccal armature, or a smooth peculiarly built œsophageal tube. Food particles of large size.

1. Body cylindrical. Cilia about entire body ..... Genus * *Nassula* p. 440
   Body flat 2
2. *a.* Without a caudal process 3
   b. With a caudal process 4
3. *a.* Anterior end angular on left side ..... Genus *Chlamydodon*
   b. Anterior end rounded ..... Genus *Orthodon*
4. *a.* Dorsal striæ and cilia present, ventral cilia longer ..... Genus * *Chilodon*, p 440
   b. Dorsal striæ and cilia absent; posterior end not pointed ..... Genus *Scaphidiodon*
   c. Dorsal striæ and cilia absent; posterior end pointed 6
5. *a.* Caudal spine with posterior bristle-like cilia ..... Genus *Trochilia*
   b. Caudal spine without posterior bristle-like cilia, ventral cilia reduced ..... Genus *Ægyria*
6. *a.* With pigment spot on anterior angle ..... Genus *Onychodactylus*
   b. Without such pigment spot ..... Genus * *Dysteria*, p. 441
   c. Cilia on right edge only of greatly reduced ventral surface

Genus NASSULA Ehr. '33.

(Dujardin '41; Stein '67; Cienkowsky '55; Cohn '66; Clap. et Lach. '58; Kent '81; Maupas '83; Entz '84; Fabre-Domergue '88; Bütschli '88; Shevyakov '96.)

The body is ovoid or cylindrical, with well-rounded ends, and in some cases slightly flattened. The mouth is ventral and placed some distance from anterior end ($\frac{1}{4}$ to $\frac{1}{3}$ total length). A slight depression on the ventral surface marks the mouth region, which is further indicated by larger and more powerful cilia. The rest of the body is uniformly ciliated. The entire body is marked by clearly defined spiral stripes. The mouth is circular and the œsophagus is supported by a considerable armature, which usually extends dorsally and to the left, rarely to the right. In some cases the structure of this armature is indistinct; again it can be clearly seen to consist of definite rods (*Stäbchen*). The anus is probably always terminal. Contractile vacuoles are variable in different species. In some cases there is but one, which is placed at the posterior end or centrally on the ventral side; in others there may be four—two dorsal and two ventral. In many cases trichocysts are uniformly distributed. Sometimes the body is colorless; again, and more often, it is brightly colored with red, blue, brown, or black pigment. The macronucleus is globular and central, occasionally band-form and with numerous attached micronuclei. Food substance varied, usually vegetable matter, see, however, below. Cysts are globular. Movement is a steady progression, combined with rolling.

Nassula microstoma Cohn '66. Fig. 34.

Synonyms: *Paramœcium microstomum* Cl. et Lach. '58, Gourret et Roeser '88; *Isotricha microstomum* Kent '81.

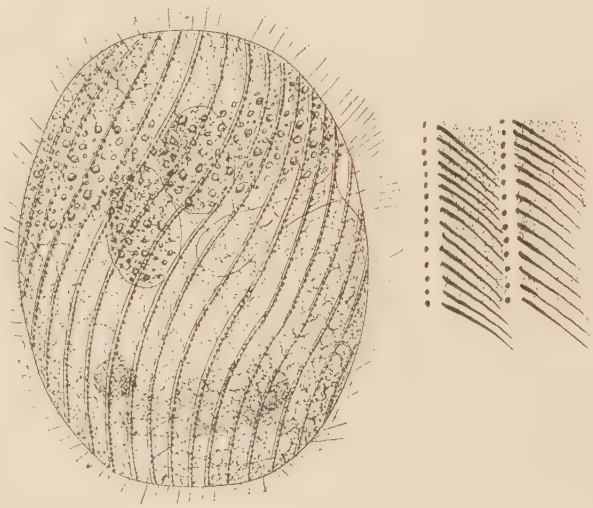


FIG. 34.—*Nassula microstoma.*

Body subcylindrical, rounded at each extremity, not quite twice as long as broad. A slight depression on one surface marks the position of the mouth, this depression being indicated by a row of longer cilia. The mouth is extremely small and is surrounded by a curious buccal armature. This is not made up of bars or rods, as in most species of *Nassula*, but appears perfectly smooth and uniform except for the considerable swelling at the inner end. The cuticle is firm and unyielding and marked by longitudinal and somewhat spiral rows of cilia and trichocysts. Under the microscope this is one of the most pleasing forms found at Woods Hole. Its color is yellowish brown from the presence of brilliant particles of coloring matter held in the cortical plasm, and, as it slowly rolls along, these particles and the black trichocysts give to the organism a peculiar sparkling effect. The macronucleus is almost central; the contractile vacuole posterior. The endoplasm appears well filled with food bodies, some of which could be distinguished as *Amphidinium* and *Glenodinium*.

Length 55μ; greatest diameter 30μ.

Genus CHILODON Ehr.

(Dujardin '41; Engelmann '78; Stein '54, 58; Kent '81; Bütschli '88; Gruber '83; Cienkowsky '55; Möbius '88; Clap. et Lach '58; Wrzesniowski '65; Shevyakov '96.)

Small forms, greatly flattened dorso-ventrally and almost egg-form in outline. The anterior end is bent distinctly to the left and forms a characteristic process, which, together with the entire margin of the body, is soft and flexible. The posterior end is, as a rule, broadly rounded. The ventral surface is finely striate, and this surface alone is ciliated. The lines of cilia converge at the mouth, and at this region the cilia are somewhat larger and more distinct, thus forming a functional adoral zone. The mouth is median and is situated in the anterior half of the body. It is surrounded by a well-defined armature, composed usually of from 10 to 16 rods. The contractile vacuoles are quite varied and from one to many in number, the number increasing with the size of the individual. The macronucleus is

usually single, elliptical in form, and centrally placed; one micronucleus. Reddish granular pigment and trichocysts are occasionally present.

Chilodon cucullulus Müll., sp. Fig. 35.

Synonyms: *Colpoda cucullus* O. F. Müller; *Loxodes cucullulus*? *Chilodon uncinatus* Ehr. '58, Perty '52, Dujardin '41; *L. dentatus* Duj., etc.

This extremely variable form has received so many different names that it hardly pays to enumerate them. It is one of the commonest and most widely spread ciliates known, although at Woods Hole I was surprised to see it so rarely. It is the type species of the genus and needs no further description. The specimens observed at Woods Hole had numerous contractile vacuoles and were 42 to 45μ long and from 28 to 32μ wide.

Genus DYSTERIA Huxley '57.

(Cl. et Lach. '58; Entz '84; Möbius '88; Shevyakov '96.)

Small forms, firm in outline, and colorless or slightly colored. The body is somewhat clam-shaped, flattened, slightly curved or straight on the right side, the other more convex. The true ventral side is only a narrow strip along the right and anterior edge of the body, the apparent ventral side being a fold of the very large dorsal surface which comes around ventrally, forming a valved structure somewhat analogous to a clam shell. Cilia are limited to the outer edge of the small ventral surface, which also bears a peculiar spine at the posterior end. Behind this spine are larger cilia. The mouth

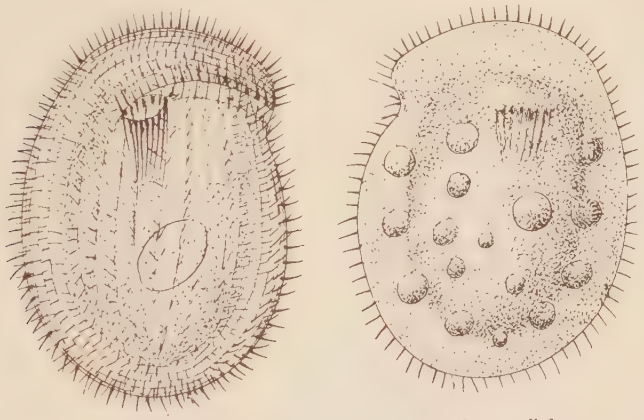


FIG. 35.—Ventral and dorsal aspects of *Chilodon cucullulus*.

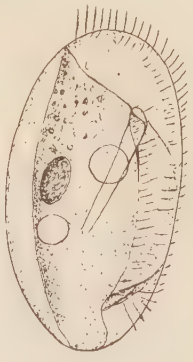


FIG. 36.—*Dysteria lanceolata*.

opening lies in the anterior widened portion of the ventral surface and is connected with a smooth tubular pharynx. The right half of the dorsal side, *i. e.*, the apparent dorsal side, is arched and bears longitudinal ridges. Two to four contractile vacuoles are placed on the ventral side. The macronucleus is usually dorsal, elliptical, and cleft, with one micronucleus attached. Fresh and salt water.

Dysteria lanceolata Cl. et Lach. Fig. 36.

Synonym: *Cyprídium lanceolatum* Kent '81.

Outline of the flattened body ovoid; body consists of two valve-like portions; the edge of the right valve is nearly straight, that of the left valve more or less sinuous; anteriorly it is cut away, obliquely and posteriorly it has a deep indentation in which the seizing spine rests. The cilia are confined to the ventral surface, here reaching, however, from the anterior dorsal extremity to below the posterior indentation. Posteriorly the cilia become larger, corresponding to the larger cirri of *D. armata*, which are posterior to the spine. The mouth lies between the two valves and is surrounded by a long and smooth buccal armature which passes downward and backward to the left a distance equal to about half the entire body length. The macronucleus is situated in the dorsal region in the central part of the body. There are two contractile vacuoles, one behind the center of the buccal armature, the other near the inner end of this organ. Movement is in circles, the animal moving around quite rapidly when not attached by its posterior process. It is colorless and measures 45μ in length by 27μ in width. Claparède & Lachmann and Shevyakov describe it as 70μ long.

Key to marine genera of Chiliferidæ.

Diagnostic characters: Mouth never lies behind the middle of the body; the œsophagus is but slightly developed. The undulating membranes are placed either on the edge of the mouth or in the œsophagus. A peristomial depression leading to the mouth is absent or very slightly indicated.

1. Mouth in the anterior half, undulating membrane on left edge only; right edge continued in a long ventral furrow ..... Genus * *Frontonia*, p. 442
2. Two undulating membranes; mouth central; no caudal bristles ..... Genus * *Colpidium*, p. 443
3. Two undulating membranes; caudal bristle ..... Genus * *Uronema*, p. 443

Genus FRONTONIA Ehr. (Cl. & Lach. '58?).

(Ehrenberg, subgenus of *Bursaria* '38; Claparède & Lachmann '58; Bütschli '88; Shevyakov '96.)

Form elongate and cylindrical, or often flattened dorso-ventrally, with round or pointed ends. It is usually plastic and contractile. Cilia are evenly distributed about the body and are similar in length. The large, open mouth lies on the anterior half of the ventral surface, and is elongate and oval in outline. On its left edge is a well-defined membrane which stretches across to the right side of the mouth. On the right edge is a small, longitudinally striped tract which is free from trichocysts and smooth in appearance. This tract is continued posteriorly in a long furrow, which in some cases reaches the pos-

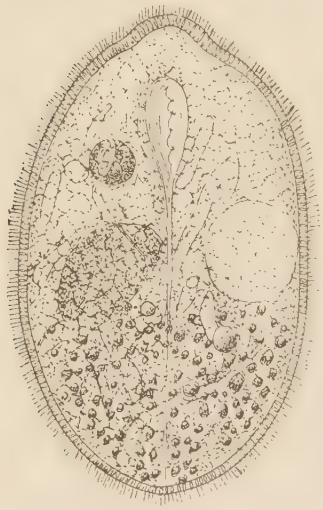


FIG. 37.—*Frontonia leucas.*

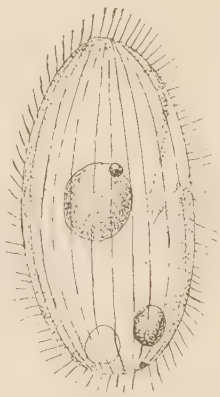


FIG. 38.—*Colpidium colpoda.*

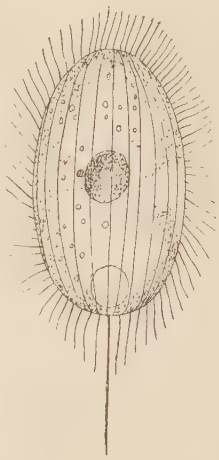


FIG. 39.—*Uronema marina.*

terior end of the animal. A few rows of cilia in this furrow vibrate differently from the others and give the effect of a membrane (Bütschli). The œsophagus is extremely short and hard to make out. The body is usually covered uniformly with trichocysts, often of considerable size. There are 1 or 2 vacuoles with long canals radiating throughout the endoplasm. The macronucleus is oval and centrally placed. Micronuclei vary from one to many. An anal opening is placed at the end of the long ventral furrow. The plasm is colorless or green by the presence of Zoochlorella, or colored brown or black by pigments. In these cases there is a considerable pigment mass on the anterior end. Movement is regular, forward, and combined with rotation. Food consists of foreign objects, diatoms, other protozoa and the like. Fresh and salt water.

Frontonia leucas Ehr. Fig. 37.

Synonyms: *Frontonia vernalis* Ehr. '38; *Bursaria leucas* Allman '55, Carter '56; *Panophrys leucas* Duj. '41, Stein '67; *Panophrys vernalis* Dujardin '41, Stein '67; *P. chrysalis* Duj. '41, Fromentel '74; *Cyrtostomum leucas* Stein '67, Kent '81.

Form ovoid, elongate, occasionally a little flattened dorso-ventrally. Mouth in the anterior third of the body. The left edge of the mouth carries a distinct undulating membrane; the right edge is plain, longitudinally striated and bears cilia. It is slightly depressed and the depression is carried posteriorly in the form of a shallow furrow which reaches to the posterior end. The contractile vacuole is on the left side, the spheroidal nucleus on the right side of the furrow. The body is uniformly

covered with fine cilia, and the periphery is uniformly studded with large trichocysts, except along the furrow. Food consists of dinoflagellates and other small forms. Color dark brown to black.

Length 330μ; width 200μ.

This form differs considerably from the fresh-water *Frontonia leucas* as described by Schewiakoff '89, especially in the extreme length of the peristomial furrow, in the position of the nucleus and contractile vacuole, and in the nature of the water canals. These in the Woods Hole form are very irregular in size and very much branched, not uniform as in Lieberkühn's (see Bütschli) figure of *Frontonia leucas*, nor radiating as in Schewiakoff's description. This may be the same species as *Frontonia marina*, of Fabre-Domergue '91, whose description and figure I have not seen.

Genus COLPIDIUM Stein '60.

(Bütschli '88; Maupas '83.)

The general form is oval, slightly compressed laterally with the dorsal side strongly arched. The ventral side is slightly incurved. The anterior end is somewhat smaller than the posterior end, which is broadly rounded. The mouth is placed some distance from the anterior end in an oral depression and opens into a tubular œsophagus. There are usually two undulating membranes which do not extend beyond the mouth borders. The right undulating membrane extends down into the œsophagus and appears to be attached to the walls of the latter. The body stripes in front of the mouth are twisted to the left. The anus is terminal and the contractile vacuole may be terminal or situated forwards in the dorsal region. The macronucleus is spherical and has one micronucleus attached. Food consists mainly of bacteria. Movement rapid, but interrupted.

Fresh and salt water, common in infusions.

Colpidium colpoda Ehr., sp. Fig. 38.

Synonyms: *Colpidium cucullus* Kent '81; *C. striatus* Stokes '85; *Kolpoda cucullus* Duj. '41; *Paramœcium colpoda* Ehr. '38, Quennerstedt '67; *Plagiopyla nasuta* Kent '81, G. & R. '86; *Glaucoma pyriformis* G. & R. '86; *Tillina campyla* Stokes '85, '88.

The body is oval, somewhat larger posteriorly, and a little compressed dorso-ventrally. The anterior end is twisted a little from the right to the left (more evident in fresh-water forms), and leans somewhat toward the ventral side. Under this portion, on the ventral side, lies the mouth in a large depression just above the middle of the body. The entire body is covered with uniform and delicate cilia, which are placed in longitudinal rows. These rows are almost straight on the dorsal side, but bend on the ventral surface, following the contour of the twisted anterior portion. The endoplasm is finely granular; the œsophagus leading into it is very distinct. Schewiakoff ('89) describes two membranes, an inner and an outer; Maupas ('83) describes them as right and left. In the present species I was able to make out only one. The macronucleus is central, spherical in form, and bears a single minute micronucleus. The contractile vacuole is posterior and dorsal to the long axis of the body. The anus is ventral to this axis and also posterior. Length 45μ; width 20μ. Common.

This marine variety is much smaller than the fresh-water form and the form differs in a number of respects, viz, in the anterior torsion and in the structure of the mouth. These may be, however, only individual variations of a widely spread species, and I believe it is perfectly safe to describe this as *Colpidium colpoda*.

Genus URONEMA Duj. '41.

(Quennerstedt '69; Cohn '66; Kent '81; Bütschli '81; Schewiakoff '89; Shevyakov '96.)

Minute forms; colorless and constant in body form. The form is oval, slightly compressed on the ventral side, while the dorsal side is distinctly arched. The membrane is distinctly marked by rather widely separated striæ. These occasionally have a spiral course about the body; in all cases they can be easily counted. The mouth is large and placed near the center of the ventral surface. It is sometimes approached by a very shallow depression or peristome from the anterior end, and marked by two rows of cilia. An undulating membrane extends down the mouth. Œsophagus absent. A long, stiff bristle extends outwards from the posterior end. The contractile vacuole is terminal or subterminal and near the anal opening. The macronucleus is spherical, centrally placed, and with one micronucleus closely applied. Movement is rapid and usual forwards in a straight line, often found resting, however, with outstretched cilia in contact with some foreign body. Food mainly bacteria. Fresh and salt water, usually in decomposing vegetable substances.

Uronema marina Duj. Fig. 39.

Synonyms: *Enchelys triquetra* Dujardin; *E. corrugata* Duj.; *Cryptochilum griseolum* Maupas '83; *Philaster digitiformis* Fabre-Domergue '85.

Small animals with ellipsoidal form and about twice as long as broad. The mouth lies in the upper half of the body and bears a well-developed undulating membrane upon its left edge. The membrane is longitudinally striped and covered with long and vibratile cilia. The right edge of the mouth bears cilia which are about the same in size as the body cilia, but are more closely inserted (Schewiakoff). The most characteristic feature is the long caudal bristle, which is extremely delicate and about two-thirds the length of the body. Schewiakoff thinks this bristle has a sensory function. I could not make this out, for although other protozoa ran against this bristle, often bending it well over to one side, the animal showed no sign of irritability but lay quiescent. A spherical macronucleus with attached micronucleus lies in the center of the body. The contractile vacuole is posterior in front of the bristle. The macronucleus was found to be double, as though just divided, in a large percentage of cases. This may be a precocious division of the nucleus long before signs of the body division are evident. Such a phenomenon, however, is rare, the macronucleus usually dividing at a late stage of cell division. Length 30 to 50μ; width 15 to 20μ. Common in decomposing algæ.

Key to marine genera of Pleuronemidæ.

Diagnostic characters: The mouth is at the end of a long peristome running along the ventral side; the body is dorso-ventrally or laterally compressed. The entire left edge of the peristome is provided with an undulating membrane which occasionally runs around the posterior end of the peristome to form a "pocket" leading to the mouth. The right edge of the peristome is provided with a less-developed membrane. There may or may not be a well-developed pharynx.

Body small; not produced into neck-like elongation.....Genus * *Pleuronema*, p. 444
Body medium-sized; anterior end produced into neck-like elongation.....Genus * *Lembus*, p. 445

Genus PLEURONEMA Dujardin '41.

(Perty '52; Clap. & Lach. '58; Stein '59, vol. 1; Quennerstedt '67; Kent '81; Bütschli '88; Schewiakoff '89; Shevyakov '96.)

Small to medium-sized ciliates, with an unchanging form. They are somewhat lens-shape and laterally compressed, the two surfaces about equally arched. The ventral surface is nearly straight or but slightly arched; the dorsal is quite convex. The anterior and posterior extremities are equally rounded. The peristome begins as a small depression, but becomes larger until it takes in nearly all of the ventral surface. The depression becomes much deeper at about the center of the body, and is especially marked on the left side of the peristome. In this deeper portion is the mouth, with an almost imperceptible œsophagus. Upon the left edge of the peristome is a high, undulating membrane, sail-like in appearance when extended. This may stretch around the posterior edge of the peristome and upon the right side, thus forming a pocket by means of which the food particles are directed into the mouth. The rest of the right edge of the peristome is occupied by closely approximated powerful cilia (Bütschli) or a second undulating membrane (Stein). The body cilia are relatively long. Trichocysts and caudal bristles may be present. The contractile vacuole is subterminal and dorsal; it is questionable whether there are canals leading to it. A round macronucleus with one micronucleus is in the anterior half of the body. The anus is terminal. Food is chiefly bacteria. Movement combines springing with swimming and rotation. Fresh and salt water.

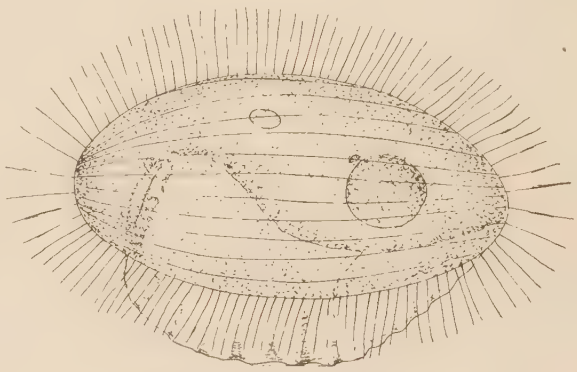


FIG. 40.—*Pleuronema chrysalis.*

Pleuronema chrysalis Ehr., sp. Fig. 40.

Synonyms: *Pleuronema crassa* Dujardin '41; *P. marina* Duj. '41; Fabre-Domergue '85; *P. coronata* Kent '81; *Paramœcium chrysalis* Ehr. '38; *Lembadion orale* G. & R. '88; *Histiobalantium agile* Stokes '85, '88.

The body is ovoid, slightly flattened, rounded at both ends, the anterior end sharper than the posterior. The ventral surface is almost entirely taken up by a peristome which extends from the

anterior end posteriorly three-quarters of the body length. The posterior end of the peristome is straight, the left curved, following the depressed portion. The body is covered with fine cilia in longitudinal lines, except on the peristome. The mouth is small and situated in the hollow of the peristome near the left border. On the left peristome edge is a large undulating membrane. It begins near the anterior end of the body and increases in height posteriorly following the peristome edge around on the right side. This posterior bend of the membrane causes the appearance of a full sail, so often seen. It can be entirely withdrawn and folded together in the peristome. On the right edge of the peristome are large, powerful cilia. The contractile vacuole is central and dorsal; the macronucleus is in the anterior half of the body, with one attached micronucleus. Food consists of bacteria. Not very common. Fresh and salt water. It often remains quiet, with membrane and cilia outstretched, as though dead, but suddenly gives a spring and is gone.

Pleuronema setigera, n. sp. Fig. 41.

Body colorless, elongate, and with the general form of a cucumber, the posterior end being somewhat pointed. The mouth and relatively small peristome are situated in the lower third of the body. The peristome begins as a shallow furrow at the center of the ventral surface and dips sharply into the buccal depression, which is deep and turned toward the posterior end. The left edge of the peristome bears a high undulating membrane, which extends anteriorly only as far as the center of the body; posteriorly it passes around to the right edge of the peristome, thus forming the characteristic membranous pocket. Inside the oral depression is a second undulating membrane, running down to the

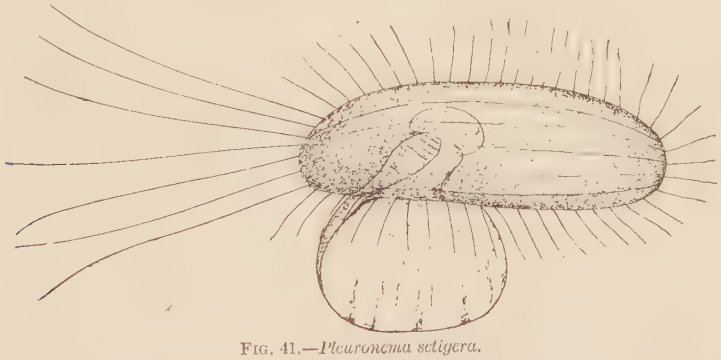


FIG. 41.—*Pleuronema setigera.*

mouth. This is small and without an œsophagus. The body is clothed with long setose cilia which are frequently fully outstretched when the animal is resting, a slight tremor of the large membrane alone indicating vitality. Posteriorly these appendages are drawn out into long filiform setæ, the number varying in different individuals from three to nine or ten. These are extremely fine and difficult to see without a high power (*e. g.* $\frac{1}{12}$ oil) and careful focussing of the substage condensor. Like *P. chrysalis*, the resting periods are terminated by sudden springs, otherwise the movements are steady and forward. The macronucleus is central, and the contractile vacuole posterior and terminal. Length 45μ to 50μ; greatest diameter 17μ. In decaying algæ.

It was this form, I believe, that Peck '95 described as a "ciliate."

Genus LEMBUS Cohn '66.

(Cohn '66; Quennerstedt '69; Kent '81; Fabre-Domergue '85; Gourret & Roeser '88; Bütschli '88; Shevyakov '96.)

Free-swimming animals of elongate form, more or less elastic and flexible, bending readily to avoid obstacles, etc. The anterior half is usually drawn out into a slightly curved neck-like portion. The peristome is a small groove leading from the anterior end to the mouth about midway down the ventral side of the body. Bütschli, following Quennerstedt, describes an undulating membrane on each side of the peristome groove. Other observers, however, usually describe but one, the left, which is clearly defined and stretches out some distance from the body, while the right border is described as having smaller but very active cilia. The general body surface is clothed with fine, uniform cilia, and body striæ are usually absent. One or more caudal bristles may be present. The

contractile vacuole is posterior and terminal, and may be multiple. The macronucleus is spherical and perhaps double (Kent). Food is chiefly bacteria, and the animals are frequently found with the anterior end embedded in zoogloea masses. Salt water, usually in infusions.

Lembus infusionum, n. sp. Fig. 42.

The body is elongate, lancet-shaped, with a tapering anterior extremity. The dorsal outline is concave through the bending of the anterior end, while the ventral outline presents an even, convex curve. The mouth lies slightly above the center of the body and marks the posterior limit of the ventral peristomial groove, which curves slightly from the anterior extremity. Each side of this groove bears an undulating membrane, the left being much larger and conspicuously striated. The general form of this left membrane is triangular, the widest part is anterior, the narrowest at the mouth. The right membrane is similar in form, but smaller and more active. The endoplasm is colorless and finely granular, not regionally differentiated. The ectoplasm consists of a relatively thick cortical plasm specially noticeable in the posterior half of the body and a delicate cuticle which bears almost imperceptible longitudinal markings—the insertion points of the fine cilia. The body is covered with uniform cilia except at the anterior extremity. Here they are much larger and bristle-like. I was unable to find any cilia in the peristome. One long caudal bristle, one-quarter of the length of the body, trails out behind. The macronucleus is spheroidal and placed near the center of the body; a conspicuous micronucleus lies near it. A row of contractile vacuoles extends from the posterior end. I have seen as many as six of nearly equal size and one or two smaller ones. The intervals of contraction are quite long. Length 70 to 75μ; greatest diameter 10 to 12μ.

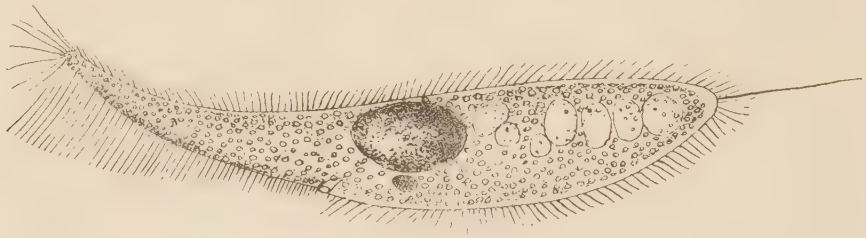


FIG. 42.—*Lembus infusionum.*

L. infusionum resembles *L. elongatus* in its general form and in its mode of life, for it excavates a retreat in zoogloea masses and lies there for considerable periods perfectly quiet. It differs from *L. elongatus* and from *L. velifer* (probably the same as *L. elongatus* of Claparède & Lachmann) in the presence of the caudal bristle, in the absence of annular markings, number of contractile vacuoles, and in the slightly smaller size. It resembles *Lembus verminus* (Müller) as described by Kent (*Proboscella vermina*), and *L. intermedius* as described by Gourret & Roeser (*Lembus verminus* syn.) in the absence of annular markings and in the presence of a caudal bristle. It differs from the former, however, in the absence of a tentacle-like process, and from both in the absence of a double nucleus and in the presence of many vacuoles. These features are so characteristic of all the specimens examined that I have concluded, somewhat reluctantly, to give it a specific name. It is common in old infusions of algæ, especially after decomposition is well advanced. Its food consists of bacteria.

Lembus pusillus Quennerstedt '69. Fig. 43.

Synonym: *L. subulatus* Kent '81.

This species is much smaller than the preceding, and might easily be mistaken for *Uronema marina*. It is subcylindrical in form, the anterior end bluntly pointed, the posterior end rounded. The oral apparatus is quite different from *Uronema*. The mouth, as in the preceding species, is at the end of a long peristomial groove extending from the anterior end to the middle of the body. The edges of the peristome bear undulating membranes as in *L. infusionum*. Like the latter, there is one caudal bristle, but unlike it there is only one posterior contractile vacuole, while the endoplasm is filled with large granules or food balls. The cuticle is distinctly striated with longitudinal markings, and the cilia are uniform in length.

Habitat similar to that of *L. infusionum*, in zoogloea masses. Length 26 to 30μ; diameter 7 to 8μ.

Although Quennerstedt's description of *L. pusillus* makes no mention of a caudal bristle, the size and other characters are so closely similar that I hesitate to make a new species. The bristle is extremely delicate, scarcely thicker than a cilium, and easily overlooked, yet with proper focussing of the condenser I found it on every specimen examined.

FIG. 43.—*Lembus pusillus.*

Key to marine genera of Opalinidæ.

Diagnostic characters: The form is oval, and the body may be short or drawn out to resemble a worm. They are characterized mainly by the absence of mouth and pharynx.

Anterior end not pointed; body cylindrical; tapering.....Genus **Anoplophrya*, p. 447
Anterior end pointed; body elongate; cylindrical; tapering .....Genus *Opalinopsis*

Genus ANOPLOPHRYA Stein '60.

(Stein '60; Claparède '60; Leidy '77; Vejdovsky '79; Kent '81; Balbiani '85 ; Bütschli '88; Shevyakov '96.)

The general form is elongate, cylindrical or slightly flattened, with rounded ends, the posterior end tapering. The body is striated with clearly defined, often depressed lines, which run longitudinally and sometimes spirally. The contractile vacuoles are usually placed in rows upon the edges. The macronucleus is almost always long and band-formed, rarely oval, and generally extending through the entire length of the body. Micronuclei have been made out in one case. Reproduction is effected by simple cross division or by budding at the posterior end, and is frequently combined with chain formation. The main characteristic is the entire absence of mouth and œsophagus, the animals being parasitic in the digestive tract of various annelids. Parasites, salt-water forms.

FIG. 44.—*Anoplophrya branchiarum.*

Anoplophrya branchiarum Stein '52. Fig. 44.

A. circulans Balbiani.

The body is cylindrical to pyriform, in the latter case broadened anteriorly. Cuticle distinctly marked by longitudinal striations which take the form of depressions and give to the body a characteristic melon shape. The endoplasm contains a number of large refringent granules—probably body products. The nucleus is elongate, somewhat curved, and coarsely granular. A micronucleus lies in the concavity. The cilia are long, inserted rather widely apart along the longitudinal markings. The contractile vacuole is single and is located at the pointed end, which is directed backwards during locomotion. One specimen found free swimming among some algæ.

Length 104μ; greatest diameter 36μ.

I was much surprised to find this form swimming about freely in the water; its mouthless condition showed it to belong to the family of parasites, the *Opalinidæ*. As the name indicates, however, this species is an ectoparasite upon the gills, and Stein gave the name *branchiarum* to a fresh-water form parasitic upon *Gammarus pulex*. The Woods Hole form is so strikingly similar to the figure of *G. branchiarum* that, although the name was given to a fresh-water form, it obviously applies to this marine variety. One important difference is the presence of only one contractile vacuole in the marine form.

Key to families of Heterotrichida.

Cilia cover the body 1
Cilia reduced to certain localized areas 2

1. *Polytrichina.*
   a. The mouth terminates a long peristomial furrow having an adoral zone along the entire left edge ..... Family *Plagiotomidæ*
   b. Peristomial area a broad triangular area ending in mouth ..... Family *Bursaridæ*
   c. Peristomial depression short; limited to the anterior end; its plane at right angles to the long axis of body; surface of peristome striated and ciliated; no undulating membranes ..... Family *Stentoridæ*
2. *Oligotrichina.*
   a. Peristome without cilia; cilia limited to one or more girdles about body ..... Family *Halteriidæ*
   One marine genus ..... **Strombidium*, p. 449
   b. Thecate forms; the body is attached by a stalk to the cup; within the adoral zone is a ring of cilia ..... Family *Tintinnida*
   c. The peristomial depression is deep and funnel-like; cuticle thick, with posterior spine-like processes ..... Family *Ophryoscolecidæ*

Key to the marine genera of Plagiotomidæ.

Diagnostic characters: The peristome is a narrow furrow which begins, as a rule, close to the anterior end and runs backward along the ventral side, to the mouth, which is usually placed between the middle of the body and the posterior end. A well-developed adoral zone stretches along the left side of the peristome, and is usually straight.

1. Body cylindrical; size medium; peristome long and turns sharply to the left at the extremity ..... Genus *Metopus*
2. No torsion in the peristome; undulating membrane is confined to the posterior part of peristome ..... Genus *Blepharisma*
3. No peristomial torsion; body highly contractile; no undulating membrane ..... Genus *Spirostomum*

Key to the marine genera of Bursaridæ.

Diagnostic characters: The body is usually short and pocket-like, but may be elongate. The chief characteristic is the peristome, which is not a furrow, but a broad triangular area deeply insunk and ending in a point at the mouth. The adoral zone is usually confined to the left peristome edge, or it may cross over to the right anterior edge.

1. The anterior half of the body tapers to nearly a point in front; the peristome is narrowest at the apex; the mouth is the entire peristome base ..... Genus *Balantidium*
2. The anterior end does not taper; the peristome is widest at the end of the body; the mouth is clearly defined ..... Genus* *Condylostoma*, p. 448

Genus CONDYLOSTOMA (KONDYLOSTOMA Bory de St. Vincent 1824) Dujardin '41.

(Dujardin '41; Claparède & Lachmann '58; Stein '59, '67; Cohn '66; Quennerstedt '67; Wrzesniowski '70; Bütschli '76, '88; Kent '81; Maupas '83; Shevyakov '96.)

Colorless and more or less flexible animals of medium size. The general form is elongate and cylindrical or somewhat smaller anteriorly. The posterior end is broadly rounded, the anterior end somewhat truncate and oblique. The peristome is broad and triangular, the base of the triangle being the entire anterior end of the body. The entire length of the peristome is one-fourth or less of the body length. The mouth is large and placed at the apex of the peristomial triangle and opens into a comparatively small œsophagus. The right edge of the peristome is lamellate and bears a clearly defined undulating membrane. The adoral zone is well developed upon the left edge of the peristome, from which it passes around anteriorly to the right edge. The surface of the peristome is free from cilia, but the rest of the body is uniformly coated with small active cilia. Contractile vacuoles are not safely determined. Bütschli thinks there is probably one terminal vacuole, but some observers deny this (*e. g.* Maupas). Others describe them on the dorsal side of the posterior end (Quennerstedt). The macronucleus is long and beaded and placed upon the right side. Micronuclei are numerous and scattered along the macronucleus. The anus is terminal and dorsal. Food consists of large and small particles. Movement rapid, free swimming, alternating with resting periods; in some cases an undulating or wriggling movement is seen, showing clearly the flexibility of the body. Fresh and salt water.

Condylostoma patens Müller. (Fig. 45.)

The body is elongate, somewhat sac-like, five or six times as long as broad, plastic, and frequently contains brightly colored food granules. The triangular peristome takes up the greater part of the anterior end, and the mouth is situated at the sharper angle of the triangle, about one-fourth of the total length from the anterior end. The cuticle is longitudinally striated, the lines having a slightly spiral course. They are not closely set, and fine cilia are thickly inserted along their edges. The endoplasm is granular and viscous. The motile organs consist of an adoral zone of membranelles,

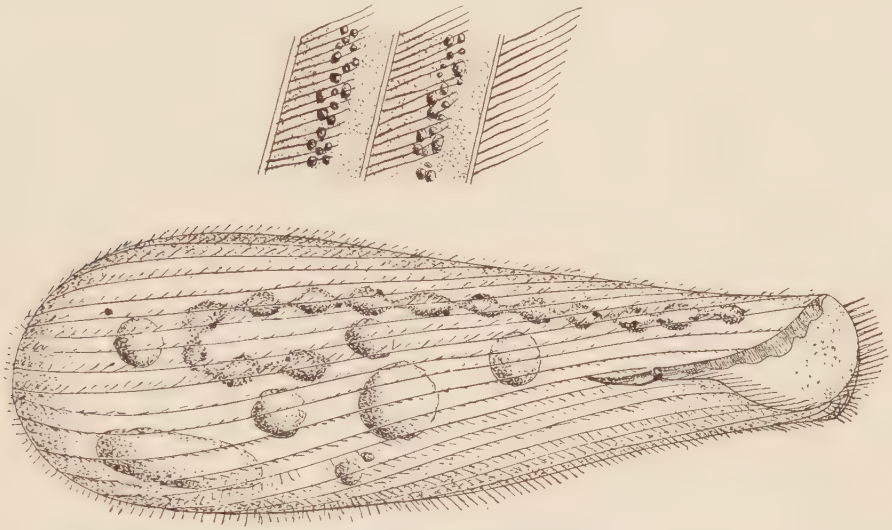


FIG. 45.—*Condylostoma patens.*

which stretch along the left edge of the peristome and the front edge of the body. The right edge of the peristome supports an undulating membrane. The nucleus is moniliform and extends the full length of the left side; a number of micronuclei are distributed along its course (Maupas).

Length 400μ; diameter at widest part 105μ. Maupas gives the length from 305μ to 495μ; and Stein 376μ to 564μ. Very common.

For a more extended account of the structures, see the excellent description by Maupas '83.

Key to the marine genera of Stentoridæ.

Diagnostic characters: The peristome is relatively short and limited to the front end of the animal, so that its plane is nearly at right angles to that of the longitudinal axis of the body. The adoral zone of cilia either passes entirely around the peristome edge or ends at the right-hand edge. The surface of the peristome is spirally striated and provided with cilia. Undulating membranes are absent.

1. Peristome circular in outline; limited to the anterior end.....Genus *Stentor*
2. The peristome is drawn out into two wing-like processes; tube-dwelling.....Genus *Folliculina*

Genus STROMBIDIUM Cl. & Lach. '58.

(Stein '67; Bütschli '73; Fromentel '74; Kent '81; Gruber '84; Entz '84; Maupas '83, Bütschli '88.)

Small, colorless (except for ingested food) animals with characteristic springing movements. The form is usually constant, but in some cases may be plastic like *Astasia;* it is usually globular or conical, the posterior end being more or less pointed, the anterior end broadest. The latter is surrounded by a complete circle of the adoral zone, the oral end of which passes into a peristomial depression which extends deep into the middle of the body. The mouth, with a very small œsophagus, lies at the bottom of the inturned peristome. The region surrounded by the adoral zone is frequently drawn out into an anterior process, occasionally bearing a pigment mass. The ventral surface in some cases bears cilia, which may be distributed or restricted to a row of large cilia. Trichocysts are usually present and

may be widely spread, limited to the posterior region, or arranged in a girdle about the middle. The contractile vacuole is simple, and posterior in position. The macronucleus is spherical and usually central in position. Movement is rapid swimming, combined with resting and floating periods, the latter usually terminated by a sudden leap.

Fresh and salt water; more common in the latter.

?Strombidium caudatum Fromentel '74. Fig. 46, *a*, *b*, *c*.

Fromentel described a fresh-water form of this genus with a caudal appendage. The body is pyriform, broadly truncate on the anterior end, in the middle of which rises a papilliform process (*Schnabel*). On this process is a heap of pigment granules, which, however, are not constant. A ring of long cirri surround the anterior end and pass into the peristome, and from the left edge of this line of cirri a large adoral zone continues down to the mouth. The peristome is elongate and sac-form, and the mouth lies at the posterior extremity. With the exception of a caudal filament there are no other motile organs; this is about half as long as the body, structureless, hyaline, and sharply

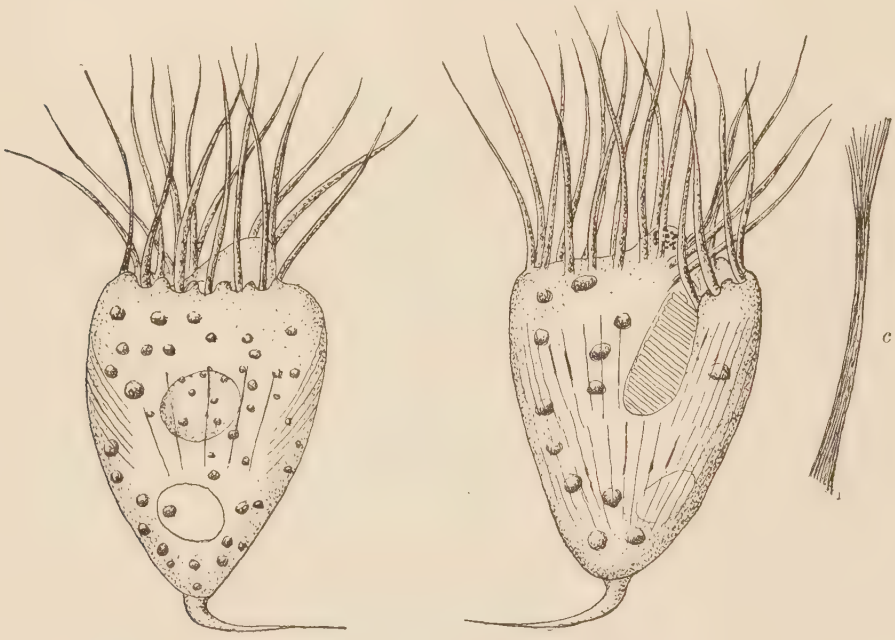


FIG. 46.—*Strombidium caudatum.*

pointed. It splits up into a bundle of fine fibers upon treatment with caustic potash (*c*). The cirri emerge from minute hollows in the edge of the anterior border. The cortical plasm contains peculiar rod-like bodies, which look more like lines or markings than like rods or trichocysts. The nucleus is large, spherical, and placed in the center of the body. The contractile vacuole is posterior.

Length without appendage is about 35μ; greatest diameter 15 to 18μ. In decaying vegetable matter. Common.

Although Fromentel's species is incompletely described, it is very evident that the organism corresponds fairly well with the Woods Hole variety. His was a fresh-water type; this is marine, but the caudal filament and the contractile vacuole are similar. Certainly in this case the organism can not be regarded as a Vorticella broken off its stalk, as Kent '81 suspected. The anterior process with its pigment spot; the cirri, the spherical nucleus, the position of the vacuole, etc., are all opposed to such an interpretation which Kent applied to the original species. Neither can it be a Tintinnoid. I place it provisionally as *S. caudatum.*

Key to the marine genera of Tintinnidæ.

Diagnostic characters: Body attached by a stalk to a cup. Inside the zone of membranelles is a ring of cilia (par-oral).

1. The test is gelatinous and more or less covered by foreign particles ..... Genus *Tintinnidium*
2. The test is chitinous and clear. No foreign particles. ..... Genus *Tintinnus*
3. The test is chitinous; covered by foreign particles, growth rings frequent ..... Genus **Tintinnopsis*
4. The test is chitinous, often covered by foreign particles. The test is marked by discoid, circular, or hexagonal spots ..... Genus *Codonella*
5. The test is perforated by pores of circular or hexagonal form ..... Genus *Dictyocysta*

Genus TINTINNOPSIS Stein '67.

(Stein '67; Kent '81; Daday '87; Bütschli '88.)

Medium-sized ciliates, inclosed in a chitinous lorica with embedded sand crystals. The form of the house, or lorica, varies greatly. In some cases the mouth opening is wide, giving the lorica a bell form; it may be long and tubular, short and spherical, or variously indented. The animal is attached, as in the closely allied genus *Tintinnus*, by a peduncle to the bottom of the lorica. The anterior end of the animal is inclosed by two complete circles of cilia; one, the outer, forming the adoral zone, is composed of thick tentacle-like membranelles, the other consists of shorter cilia within the adoral zone. The mouth leads into a curved œsophagus containing rows of downward-directed cilia (Daday). The entire body is covered with cilia, but as the lorica is always opaque these can be made out only when the animal is induced to leave the house. The only difference between this genus and *Tintinnus* is the covering of foreign bodies—usually sand crystals. Movement is rapid and restless, and peculiarly vibratory, owing to the apparent awkwardness in moving the house. Salt water.

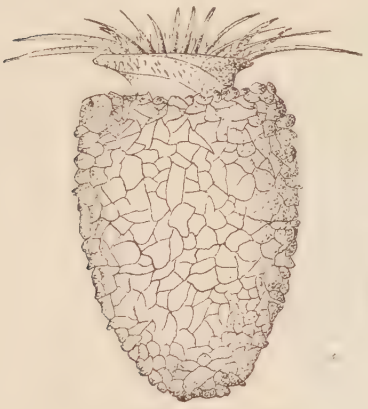


FIG. 47.—*Tintinnopsis beroidea.*

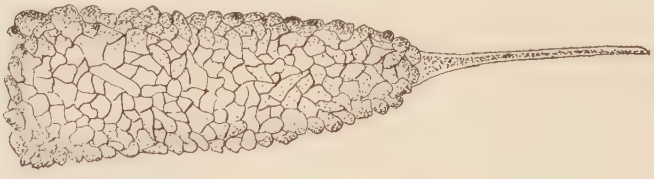


FIG. 48.—*Tintinnopsis davidoffi.*

Tintinnopsis beroidea Stein, var. **plagiostoma** Daday. Fig. 47.

Synonym: *Codonella beroidea* Entz '84.

The shell is colorless, thimble-shaped, with a broadly rounded posterior end. The body is cylindrical. The internal organs were not observed. Membranelles 24 in number.

Length 50μ; greatest diameter 40μ.

Var. **compressa** Daday '87.

The posterior end of the shell is pointed, the lower third of the shell is swollen, the upper third is uniform in diameter and without oral inflation or depression. Nucleus not seen.

Length 70μ; greatest diameter 48μ.

Tintinnopsis davidoffi Daday. Fig. 48.

The shell is large, elongated, and provided with a considerable spine. The chitin of the shell is covered with silicious particles of diverse size. The internal structures were not observed.

Length of shell and spine 230μ; diameter of the oral aperture 54μ.

The variations of these species are considerable, and as the internal structures, such as the nucleus, are essential in fixing their systematic position, I place them as above, provisionally, and until further observations can be made.

Key to families of Hypotrichida.

a. Peristome indistinct; cilia on ventral surface uniform and not differentiated into cirri ..... Family *Peritromidæ*
One genus, **Peritromus* ..... p. 452
b. Peristome more or less indistinct; cilia reduced to a few rows on the ventral surface; anal and frontal cirri present ..... Family *Oxytrichidæ*
c. Cilia entirely reduced; frontal and anal cirri present or reduced; macronucleus band-formed or spherical ..... Family *Euplotidæ*
d. Peristome reduced to left edge and does not reach over the anterior margin ..... Family *Aspidiscidæ*
One genus, **Aspidisca* ..... p. 458

Genus PERITROMUS Stein '62.

(Stein '62, '67; Maupas '83.)

The body is flat, colorless or tinged with yellow, and contractile. It is elliptical in outline, with broadly rounded ends; in some cases the left edge is slightly incurved, the right edge convex. The ventral surface is flat, the dorsal surface is arched in the middle region of the body. The edges being flat are somewhat more transparent than the remainder of the body. The ventral surface is striated by longitudinal straight or slightly curved lines, the dorsal surface is smooth and without cilia. (Maupas describes bristles on the back, but this is not corroborated.) The adoral zone is fairly well developed, but not distinctly marked off from the remaining ventral surface. It begins on the right side and extends entirely around the frontal margin and down the left side below the middle of the body, where it turns suddenly to the right, entering the slightly insunk peristome. The mouth leads into a short, indistinct œsophagus. One contractile vacuole is situated in the dorsal swelling at the posterior end of the animal. Macronucleus double, one in each side of the dorsal swelling. Movement is slow and creeping, with a peculiar method of contracting the more hyaline edge, which may turn upward or around a foreign object.

Fresh (?) and salt water.

Peritromus emmæ Stein. Fig. 49.

With the characters of the genus.

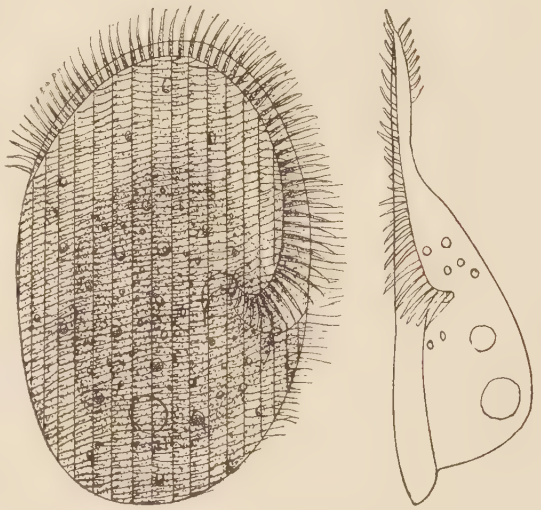


FIG. 49.—*Peritromus emmæ*, ventral and lateral aspects.

Key to the marine genera of Oxytrichidæ.

Diagnostic characters: The peristome is not always marked off from the frontal area. In the most primitive forms the cilia on the ventral surface are similar to those of the preceding family (*Peritromidæ*). Usually some of the anterior and some of the posterior cilia are fused into cirri, distinguished as the frontal and anal cirri, respectively. In the majority of forms all of the cilia are thus differentiated; strong marginal cirri are formed in perfect rows, and ventral cirri in imperfect rows. In addition to the adoral zone there is an undulating membrane on the right side of the peristome, and in some cases a row of cilia between the membrane and the adoral zone. These are the par-oral cilia and they form the par-oral zone.

1. The posterior end is pointed or tail-like 2
The posterior end is rounded; not tail-like 5
2. The front end is pointed 3
The front end is rounded 4
3. Frontal and anal cirri absent; often tube-forming ..... Genus *Stichotricha*
Eight frontal and 3 caudal cirri; not tubicolous ..... Genus *Gonostomum*
4. Anal cirri present; with or without short lateral bristles ..... Genus **Epiclintes*, p. 453
Anal cirri absent; no bristles ..... Genus *Uroleptus*
5. With frontal cirri 6
No frontal cirri; 2 to 3 rows of ventral cirri; anal cirri small ..... Genus *Holosticha*

6. Right margin of peristome straight as far as the anterior end; 5 rows ventral cirri; 5 anal cirri ..... Genus *Oxytricha*
   Right margin of peristome curved 7
7. Five rows or less of ventral cirri 8
   More than 5 rows of ventral cirri ..... Genus *Urostyla*
8. Membranelles normal; 5 to 10 anal cirri; no caudal cirri ..... Genus **Amphisia*, p. 453
   Membranelles normal; 5 to 10 anal cirri; 3 caudal cirri ..... Genus *Stylonychia*
   Membranelles very large and powerful; adoral zone not continued to mouth; 5 anal cirri ..... Genus *Actinotricha*

Genus EPICLINTES Stein '62.

(Stein '62, '64, '67; Mereschowsky '79; Gruber '87; Bütschli '88.)

Very active, contractile, colorless forms of rather small size. In the fully expanded condition the body is oval and long, with its greatest width in the center or at the front half of the body. The posterior end is always drawn out into a relatively long tail, which is extremely elastic. The peristome is short and stretches around the front end of the animal. In the frontal region are from one to three rows of cirri. The ventral surface is covered with longitudinal rows of cilia, the number of rows being in dispute (6 to 7 according to Stein; 9 according to Mereschowsky and Rees). Some of these cilia project from the lateral edges and from the posterior end, where they are slightly elongated. The anus is dorsal and placed at the beginning of the posterior process. Macronucleus probably double. Movement is rapid and restless, the tail process contracting to jerk the body backward. Salt water.

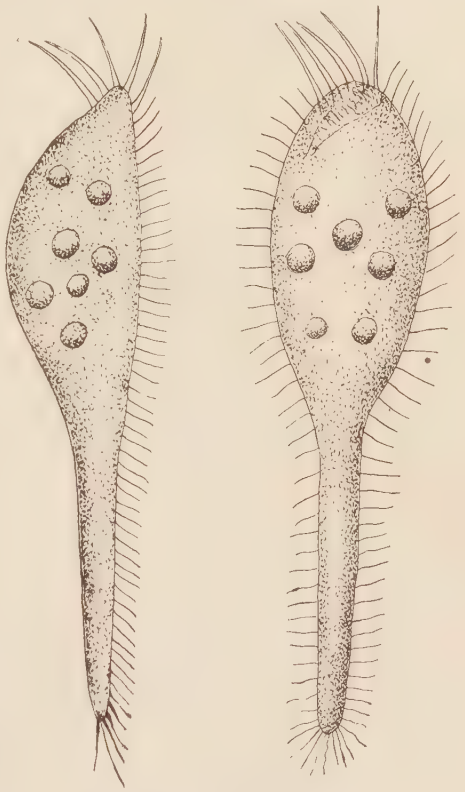


FIG. 50.—*Epiclintes radiosa*.

Epiclintes radiosa Quenn. Fig. 50.

Synonym: *Metra radiosa* Quenn.

The body is elongate, slightly narrowed anteriorly, and drawn out posteriorly into a long, retractile, tail-like portion. Five large cirri extend outward from the anterior extremity. The caudal portion may be extended to a distance equal to twice the length of the body or contracted to half the length. The peculiar nervousness of this form made it extremely difficult to study, and the oral region was imperfectly made out. The anterior cirri appear to line the upper left border of the peristome, which is marked by a row of large cilia. The peristome begins upon the right side of the anterior end and passes backward and to the left, narrowing at this point. The mouth is very small and difficult to see. It is apt to stay in one locality under zoogloea, switching back and forth with great vivacity, or hanging on by the posterior cilia while the anterior end stretches out in the surrounding medium. Nucleus and contractile vacuole were not observed. Length 45μ.

Genus AMPHISIA Sterki '78.

(Sterki '78; Kent '81; Bütschli '88.)

The body is plastic and soft, colorless or slightly tinged with yellow or red. In form it is oval or elongate, the posterior end is rounded and slightly reduced in diameter, but does not form a distinct tail. The anterior end is also rounded and similarly reduced in width. There are two rows of marginal cirri (*Randcirren*), which may be placed some distance from the edge, and two or three rows of ventral cirri between them. There are from 3 to 5 frontal cirri of larger size than those of the ventral rows, and from 5 to 10 anal cirri. (The genus *Holosticha* is similar in all respects save the presence of frontal cirri.) The macronucleus is double; the contractile vacuole is central and on the left

side. The peristome is long and rather narrow and carries an undulating membrane on its right margin. Fresh and salt water.

Amphisia kessleri Wrzes. '77. Fig. 51.

Synonyms: *Trichoda gibba* Müller; *Oxytricha gibba* Stein '59; *O. velox?* Quen. '69; *O. kessleri* Wrzes. '77.

Body elongate, slightly sigmoid and swollen in the center, about 3½ times as long as broad; the rounded anterior end is turned to the left, the similarly rounded posterior end to the right; both ends taper slightly. The peristome is long and narrow, with a distinct adoral zone which appears broken in its course. To the right of this adoral zone is a single line of preoral cilia. On the right border of the peristome is an undulating membrane. The three frontal cirri form a triangle and the five smaller anal cirri form a continuous line with the broken row of ventral cirri. There are two and one-half rows of ventral cirri and the marginal cirri are drawn in until they are ventral in position.

Length 135μ; greatest width 40μ.

This variety differs from *O. kessleri* as described by Wrzesniowski in having three frontal cirri instead of four. Another difference is in the structure of the nuclei and in their position. These

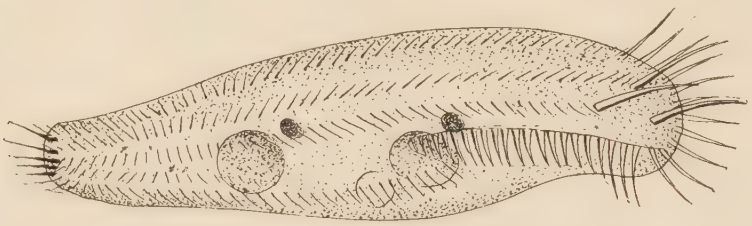


FIG. 51.—*Amphisia kessleri.*

differences are too minute to warrant a specific name. *O. velox* of Quennerstedt is probably the same as *O. kessleri*, but differs in having three complete rows of ventral cirri. *O. velox* has three frontal cirri in a line, thus differing from the Woods Hole form.

Key to the marine genera of Euplotidæ.

Diagnostic characters: Cilia, as well as the frontal, marginal, and ventral cirri, very much reduced; the anal cirri, on the other hand, are always present. The macronucleus is band-form.

1. Frontal cirri more than 8 2
   Frontal cirri less than 8 3
2. Eleven marginal cirri on the left side; 11 frontal cirri ..... Genus *Certesia*
   Four marginal cirri, 2 on each side; 9 to 10 frontal cirri ..... Genus * *Euplotes*, p. 454
3. Seven frontal, 5 anal, 3 right marginal, and 2 left marginal cirri ..... Genus * *Diophrys*, p. 456
   No frontal, 5 anal, 3 right, and 2 left marginal cirri ..... Genus * *Uronychia*, p. 457

Genus EUPLOTES (Ehr. 1831) Stein '59.

(Ehrenberg '31, '38; Stein '59; Cl. & Lach. '58; Quennerstedt '65, '67, '69; Bütschli '88; Kent '81; Gourret & Roeser '88; Möbius '88.)

Small to medium-sized forms. Rigid in form, colorless, or green by chlorophyl. They are quite flat on the ventral surface but decidedly arched dorsally, and the contour is usually oval. The anterior end is broadly rounded to truncate; the posterior end is similarly rounded, or may be somewhat pointed. The mouth is placed centrally or near the left margin, and from it the right edge of the peristome forms a curved line to the left, which bends forward, thus making the greater part of the left edge the peristomial area. In front the peristome bends sharply to the right and extends as far as the right end of the adoral zone. Upon the frontal and median ventral surface are 9 to 10 great cirri (*Bauchwimpern* of Stein). Posteriorly five great anal cirri stretch out beyond the posterior body margin. In addition to these there are two smaller marginal cirri upon the left body edge, and two similar ones on the hinder part of the body. The dorsal surface is rarely smooth, but usually is marked by longitudinal ridges, and rows of dorsal bristles have been described. The single contractile vacuole lies on the right side in the region of the anal cirri, sometimes just above them, sometimes

below. The anus is posterior and on the right side. The characteristic macronucleus is long and band-form, its main portion being usually on the left side with an anterior and a posterior arm toward the right. Movement is rapid swimming, which, however, is frequently broken by creeping periods, during which the animals appear to be examining the foreign body on which they creep.

Fresh and salt water.

Euplotes charon Ehr. Fig. 52.

Synonyms: *Trichoda charon* Müller; *Plæsconia charon; P. affinis, subrotunda, radiosa, longiremis,* Dujardin '41.

The body is oval, small, and somewhat variable in length. The carapace is strongly marked upon the dorsal side by deep longitudinal grooves, 6 to 8 in number; the grooves may be absent, however. The adoral zone extends to the posterior third of the body, the mouth and œsophagus are directed anteriorly. There are 10 ventral cirri, 7 of which are on or near the frontal border and 3 near the

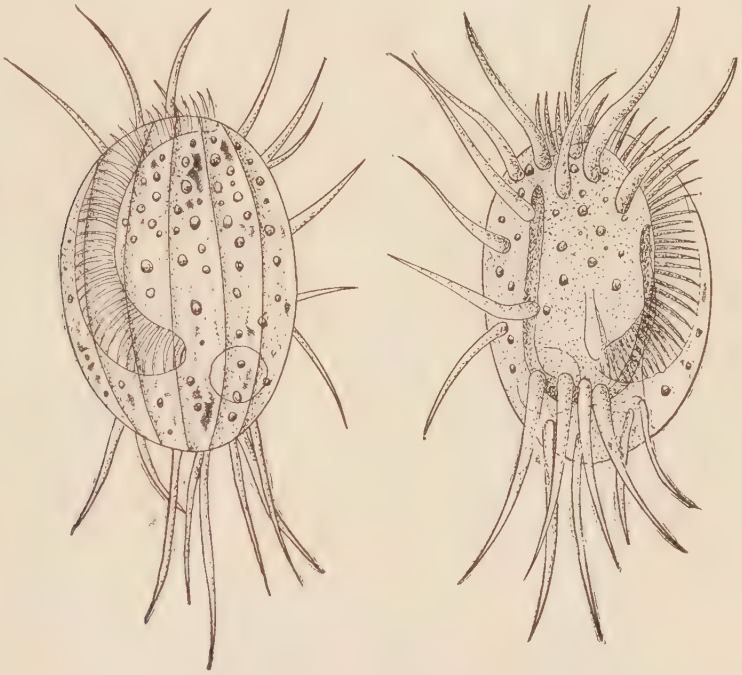


FIG. 52.—*Euplotes charon,* dorsal and ventral aspects.

right edge. There are 5 posterior cirri and 4 anal cirri, of much smaller size. The cirri may or may not be fimbriated, the latter condition indicating the approaching disintegration of the body and is abnormal. The macronucleus is long and band-formed or horseshoe shape. The contractile vacuole lies on the right side dorsal to the posterior cirri.

Fresh and salt water. Length 45μ; diameter 25μ.

Euplotes harpa Stein. Fig. 53.

The body is elongate, oval, somewhat widened anteriorly, and has rounded ends. The frontal margin is three-toothed. Ten ventral cirri. Dorsal surface provided with 8 longitudinal markings. The peristome is long and broad, with considerable variation. The adoral zone consists of powerful membranelles arranged in a continuous curve from the mouth to the extreme right frontal margin. Seven of the 10 ventral cirri are situated at the anterior extremity; the remainder are arranged in a triangle on the right edge. The anal cirri, 5 in number, are long and stiff; the marginal cirri smaller and finer. The nucleus and contractile vacuole are similar to those of the preceding species.

Length 95μ; width 54μ.

Genus DIOPHRYS Dujardin '41.

(Bütschli '88.)

Medium size, colorless to yellow, rigid in form. The body contour is oval, the anterior end being rounded or slightly reduced, the posterior end usually cut in on the right side. The peristome is broad but less extensive than in *Euplotes*, and may extend beyond the middle of the body. Its right edge is convex toward the right side, extends forward and does not turn again to the right. The anterior ventral surface has 7 to 8 scattered cirri and just behind the mouth is a transverse row of large anal cirri. In the sharp in-cut of the posterior end are three great angular cirri. Two lateral

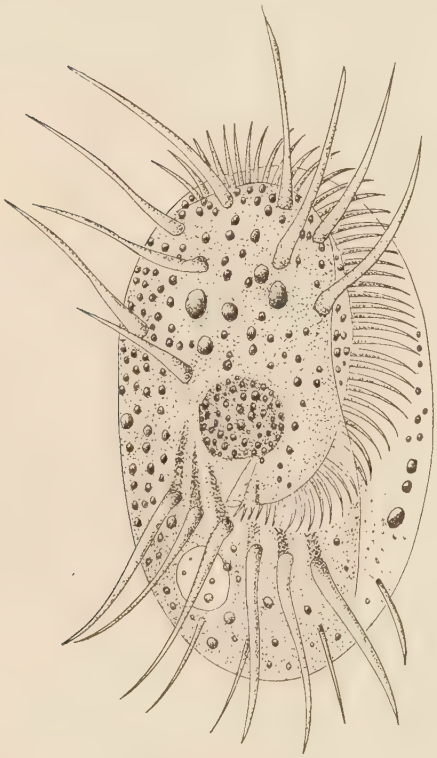


FIG. 53.—*Euplotes harpa.*

FIG. 54.—*Diophrys appendiculatus.*

cirri are placed on the left of the median line between the mouth and the anal cirri, and usually in a slight hollow. The contractile vacuole is on the right side in the vicinity of the anal cirri. The macronucleus is in two parts, each band-form, one anterior, the other posterior in position. Movement is rapid and steady. Salt water.

Diophrys (Styloplotes) appendiculatus Stein '59. Fig. 54.

Synonyms: *Styloplotes appendiculatus* Stein '59; Kent '81; Quennerstedt '67, etc.

The general form resembles *Euplotes*. Its outline is oval and regular except at the posterior end on the right side, where there is a considerable indentation. The frontal margin is characterized by a row of powerful membranelles, which become smaller at the peristome and at the mouth they are of characteristically small size. The ventral cirri are 7 in number. Five of them are in one row from the anterior end down the right side nearly to the anal cirri; 1 is on the frontal border between the first two; 1 lies just anterior to the second anal cirrus from the right side. The 5 anal cirri are large and powerful and extend some distance beyond the posterior end of the body. In all specimens observed these cirri curve to the left. Dorsal to the anal cirri and placed deep into the dorsal pit are 3 large, sharply curved cirri, which in most cases are fimbriated, but when the specimens are

normal these are pointed and curve abruptly to the right. Two smaller cirri lie to the left of the group of anal cirri. The peristome is well-marked by the adoral zone, and upon its right border there is a row of cilia, and a similar row of cilia runs along the base of the oral membranelle. The macronucleus is double and consists of two elongate cylindrical masses lying parallel with one another. One of these is in the anterior region; the other is posterior. The contractile vacuole lies dorsal to the anal cirri and anterior to the three dorsal cirri. The movement and general activities resemble those of *Euplotes*.

Length 50μ; diameter 25μ.

Genus URONYCHIA Stein '52.

(Stein '59, '67; Quennerstedt '67; Kent '81; Bütschli '88.)

Medium-sized colorless ciliates of usually constant body form. The body is somewhat short and oval in outline. The anterior end is broadly truncate, the posterior end rounded or slightly pointed. The ventral and dorsal surfaces are considerably arched and the latter usually has a number of rows of longitudinal stripes. The open peristome is broad and reaches back to the middle of the ventral surface and beyond. According to Stein, the two edges can approach each other, thus opening and closing the peristomial area. Its right edge forms a greater angle with the front edge than in the genus *Euplotes*, and the left edge forms a greater angle with the front edge than in that genus. The left edge also appears to cover over the adoral zone slightly. There are no ventral cirri in front, but on the posterior ventral surface are 7 great springing cirri. Five of these are inserted on the right side in a deep in-sinking, and the other 2 in a similar depression on the left ventral surface. Above the 5 right-side cirri, i. e., dorsal to them, but in the same depression, are 3 angular cirri. A few edge cirri are found to the left of them and another to the right of the 5 cirri. The contractile vacuole is on the left side between the main groups of cirri. The macronucleus is band-form or spherical, and is situated in the middle region of the body. Movement consists in forward swimming with sudden springs.

Salt water.

FIG. 55.—*Uronychia setigera*.

Uronychia setigera, n. sp. Fig. 55.

This species is very common in the Woods Hole waters. It is small, colorless, and very active. The most characteristic feature is the posterior end with its relatively enormous cirri, which are apparently large enough for an animal four times its size. The form is ovoid, widened posteriorly.

The ventral surface is flat and has two excavations in the posterior end. The right hollow is larger and contains 5 great cirri of unequal size, the extreme right one being the largest. The left hollow contains 2 cirri, also of dissimilar size. Dorsal to the 5 right cirri are 3 sickle-formed cirri, which are usually fimbriated. These are pointed and curve regularly to the left. The peristome is wide and open, and a small pocket-like hollow on its left border indicates the region of the mouth. The adoral zone runs into this pocket and the mouth is located in its lower right-hand corner. In *U. transfuga* the right border is generally described as having a membrane of extreme delicacy. I was unable to see such a membrane in this form, but in its place there are 2 flagella-like cirri extending from the margin of the mouth opening into the peristome, and these vibrate slowly. I do not believe these could be the moving edge of an undulating membrane, for they are quite distinct. The macronucleus is spherical instead of band-form, and a single micronucleus is closely attached. This is unlike the European species *U. transfuga*, in which the nucleus is elongate. The contractile vacuole lies between the two sets of posterior cirri. There are no marginal folds like those of the European species.

Length 40μ; width 25μ. Common.

Genus ASPIDISCA Ehr. 1830.

(Perty '52; Cl. & Lach. '58; Stein '59; Quennerstedt '65, '67, '69; Mereschowsky '79; Kent '81; Bütschli '88.)

Small, colorless, and rigid forms, with nearly circular to oval contour. The left side is usually straight, or at least but slightly convex. The right side is much more convex, and the right margin is considerably thickened. The ventral side is flat, the dorsal surface convex, with from one to several longitudinal ridges which run more or less parallel with the right edge. The peristome is limited to the left edge, where it forms a small depression which may or may not reach the anterior border, but which in no case runs around the anterior margin. The left peristome margin in some cases grows over the peristome depression toward the right, thus making a sort of cover for the peristome. In the posterior region is a deep depression, from which 5 to 12 cirri take their origin. Seven or 8 cirri are placed in the anterior half of the ventral surface and are arranged more or less in rows. The anus is on the right side in the region of the anal cirri (Stein). The contractile vacuole is generally on the right side and similarly located. The macronucleus is a horseshoe-shaped body. Movement rapid, somewhat in circles, and rather uniform.

Fresh and salt water.

Aspidisca hexeris Quennerstedt '67. Fig. 56.

The carapace is elliptical, about 1½ times as long as broad, rounded at the extremities. The left border of the carapace bears a spur-like projection. The ventral cirri are short and thick, and are very characteristic of the species. When moving slowly they look much like nicely-pointed paint brushes, but when the animal is compressed they quickly become fibrillated, and then look like extremely old and worn brushes. These cirri are placed in depressions in the ventral surface and each one appears to come from a specific shoulder. At the posterior end an oblique hollow bears 6 unequal cirri placed side by side. The extreme right cirrus is the largest, and they become progressively smaller to the opposite end. Dorsal to these lies the contractile vacuole. The peristome is in the posterior half of the body and an undulating membrane extends from it into the œsophagus. The dorsal surface is longitudinally striated by 5 or 6 lines, which are usually curved. The nucleus is horseshoe-shaped and lies in the posterior half of the body. Length 68μ; diameter 48μ.

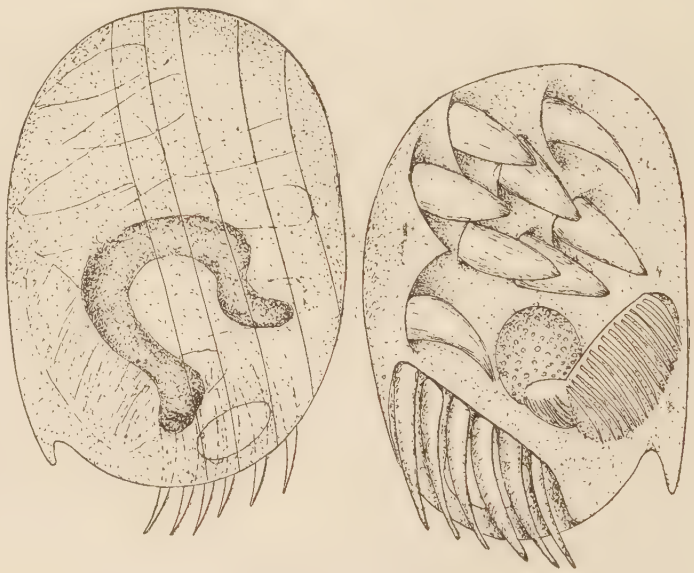


FIG. 56.—*Aspidisca hexeris.*

This form was incorrectly mentioned as *Mesodinium* sp. by Peck '95.

In the figure given by Quennerstedt there are only 7 ventral cirri. In the Woods Hole form there are 8, 7 of which are anterior, 6 of them about 1 central one. The eighth cirrus is by itself, near the base of the largest posterior cirrus. These cirri, in spite of their size, are easily overlooked and more easily confused, but by using methylene blue they can be seen and counted.

Aspidisca polystyla Stein. Fig. 57.

This species is similar to *A. hexeris*, but is smaller, very transparent, and without the spur-like process on the left edge of the carapace. The chief difference, however, lies in the number of anal cirri. These are 10 in number and they are arranged obliquely as in the preceding species, with the largest one on the right and the smallest on the left. The ventral cirri are 8 in number, and are arranged in two rows, one of which, the right, has 4 cirri closely arranged, the other having 3 cirri

close together and 1 at some distance, near the largest anal cirrus. The peristome, contractile vacuole, and nucleus are similar to the preceding. Length 36μ; width 22μ.

Stein assigns only 7 ventral cirri to this species, but he also describes 2 very fine bristle-like cilia (p. 125) and pictures them in figs. 18, 19, 20, and 21 of his Taf. III in the same relative position as my eighth cirrus. I am positive that cilia do not occur on the ventral face of this form, and that the characteristic cirri are the sole locomotor organs.

Key to families of Peritrichida.

a. Peristome drawn out into funnel-like process; parasitic ..... Family *Spirochonidæ*

b. Adoral zone and circlet of cilia at opposite end. Adoral zone left-wound. Parasitic (one genus, * *Lichnophora*). Family *Lichnophoridæ*

c. Adoral zone a left-wound spiral. Attached or unattached forms ..... Family *Vorticellidæ*

Genus LICHNOPHORA Claparède '67.

(Gruber '84; Fabre-Domergue '88; Bütschli '88; Wallengren '94; Stevens 1901.)

Small or medium-sized colorless animals, extremely elastic and flexible. The anterior part, bearing the adoral zone, is round or oval in ventral view, and has a flat ventral and a highly arched dorsal surface. The posterior end of the animal is reduced to a stalk-like structure which is broadened at the extremity to form a sucking disk. The surface of this disk and the surface of the peristome may be brought into the same plane by the characteristic bending of the stalk portion. A ciliated girdle is placed at the edge of the sucking disk. A well-developed adoral zone incloses the peristome; it begins

FIG. 57.—*Aspidisca polystyla.*

FIG. 58.—*Lichnophora macfarlandi.*

at the mouth on the left side and includes nearly all of the peristome in its left-wound spiral, the extremity approaching closely the end near the mouth. The macronucleus is a long-beaded structure, or it may be in several parts connected by strands (Gruber). The contractile vacuole is on the left side in the region of the mouth. Salt water.

Lichnophora macfarlandi Stevens. Fig. 58.

The body is elongate; oral disk variable in form, attachment disk clearly defined and constant. The stalk is very contractile and elastic, constantly changing in shape. When detached from the host the animal moves with a very irregular and indefinite motion. When attached it moves freely over the surface on its pedal disk. The latter is bordered by four membranes composed of cilia. A distinct axial fiber extends from the pedal disc to the peristome and gives off a number of branches. This fiber is analogous to the myonemes in *Vorticella*. An indistinct longitudinal furrow can be made out occcasionally. The nucleus is in 5 or 6 separate pieces, of which 1 is found in the pedal disk and 1 or 2 in the neck.

On the egg capsules of *Crepidula plana;* also reported upon annelids at Woods Hole.

Length 60μ from disk to extremity of the peristomial disk.

This form does not agree in all respects with Stevens's species, but the agreement is so close in other respects that I believe it can be safely identified as *L. macfarlandi*. The mode of life is different, and the macronucleus is different, there being from 25 to 30 fragments in Stevens's form and only 5 or 6 in the present one. There is, however, the same evidence of chain formation in both of them. The length of the oral cilia in Stevens's form is 18μ in fixed and 30μ in living forms. In the Woods Hole form the cilia are not more than half that length.

Key to the marine genera of Vorticellidæ.

Diagnostic characters: Attached or unattached forms of peritrichous ciliates in which the adoral zone seen from above forms a right-wound spiral. A secondary circlet of cilia around the posterior end may be present either permanently or periodically.

1. Posterior ciliated girdle permanent around an attaching disk 3
2. Posterior ciliated girdle, temporary during motile stage 4
3. Body cylindrical:
   (*a*) With ring of stiff bristles above the ciliated girdle ..... Genus *Cyclochæta*
   (*b*) Without accessory ring of bristles; with velum ..... Genus *Trichodina*
   Body conical; general surface ciliated ..... Genus *Trichodinopsis*
4. No test and no stalk ..... Genus *Scyphidia*
5. No test; with stalk containing contractile thread 8
6. No test; with stalk but without contractile thread ..... Genus *Epistylis*
7. With a test; with or without a stalk ..... Genus * *Cothurnia*, p. 461
8. Individuals solitary ..... Genus * *Vorticella*, p. 460
   Individuals colonial; entire colony contractile ..... Genus * *Zoothamnium*, p. 461
   Individuals colonial; parts only of the colony contractile ..... Genus *Carchesium*

FIG. 59.—*Vorticella patellina.*

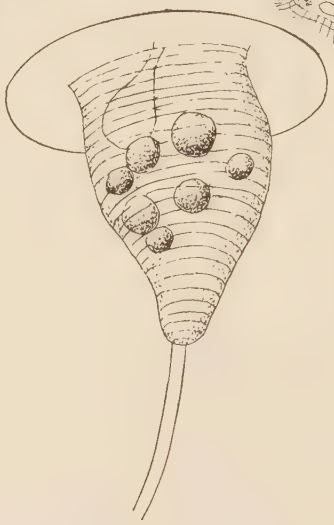


FIG. 60.—*Vorticella marina.*

FIG. 61.—*Zoothamnium elegans.*

Genus VORTICELLA (Linnæus 1767) Ehr. '38

(Bell Animalcule Leeuwenhoek 1675; Ehrenberg '38; Dujardin '41; Stein '51; Cl. & Lach. 58; Greeff '70; Bütschli '88; Kent '81; Stokes '88; etc.)

Medium-sized ciliates of general bell-like form. They may be colorless, or yellow and green through the presence of Zoochlorella. When not contracted, the peristome end is widespread, rarely narrowed. The adoral zone and peristome agree with the details given in the family characteristics. The chief character is the attachment of the posterior end by means of a single, longer or shorter, stalk, which contains a highly contractile thread easily distinguished in the living animal. Another character is the absence of colony formation. Contractile vacuole, single or double, usually connected with a sac-like reservoir. The macronucleus is invariably long and band-formed, with attached micronucleus. Fresh and salt water.

So many species of *Vorticella* have been described that the task of collecting data and of arranging the synonyms is extremely irksome and difficult. Stokes enumerates 66 species, inhabiting fresh and salt water, and several other new species have been added since his work. I am impressed with the fact that new species have been created without proper regard for the manifold variations which nearly all of the *Ciliata* show, and I believe the 66 species might be safely reduced to 12 or 15.

Vorticella patellina Müller. Fig. 59.

Body campanulate, widest at anterior border, from which it tapers directly to the pedicle. The diameter of the peristome is a little larger than the length of the body. The ciliary disk is but little elevated. The cuticle is not striated and the body plasm is quite transparent. Length 52μ.

Vorticella marina Greeff. Fig. 60.

The body is conical but variable, and may be short or elongate, so that relative length and breadth offer no chance of identification. In general the body is campanulate. The distinguishing feature is the transverse annulation of the bell.

Small, but common, and grows in small social groups. Length 35μ.

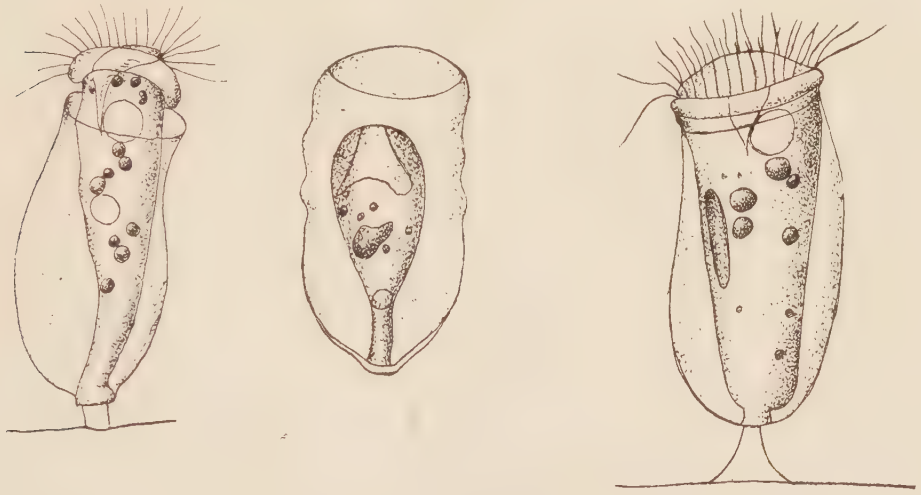


FIG. 62.—*Cothurnia crystallina.*

Genus ZOOTHAMNIUM (Bory de St. Vincent 1824) Stein '38, '54.

Colorless and highly contractile forms growing in small or large colonies. The form and structure of the individuals is not different from *Vorticella*. The colonies are usually richly branched upon the dichotomous plan and the entire colony is contractile. The main character is that with each division of the individual the stalk also divides, each daughter cell getting one-half of the parent stem. The stems therefore remain in communication, so that a simultaneous contraction results, and the colony as a whole is withdrawn. In some species so-called macrogonidia, or larger sexual individuals, are developed alongside the usual ones. Fresh and salt water.

Zoöthamnium elegans D'Udekem '64?. Fig. 61.

The bodies are variable—peristomial border widely dilated, tapering and attenuate posteriorly. The pedicle is slender, smooth, and transparent, and branches sparsely at its distal extremity. There are but few zooids (3 to 4). The ciliary disk projects conspicuously beyond the peristomial border. The pharyngeal cleft is very distinct and extends beyond center of body. Length of body 80μ.

Genus COTHURNIA (Ehr. '31) Clap. & Lach. '58.

Colorless forms of medium size—in some cases they may be green by Zoochlorella. The general structure is similar to that of *Vorticella*, but the individuals are elongate and occupy houses. The macronucleus is invariably long and band-form. The distinguishing character is the colorless or

brownish lorica of quite variable form but always attached. These houses may be finger-formed, with widened center, or widened mouth, or constricted mouth, and the like. Ring-formed swellings are frequently developed. Sometimes the mouth becomes twisted and the lorica is therefore bilateral. The houses are attached either directly to some foreign object or by means of a short stalk. The animals are similarly fastened to the lorica, sometimes directly, sometimes by means of a short stalk. When they contract they draw back to the bottom of the lorica; when expanded they usually stretch out of the mouth opening. In some forms there is an operculum, by means of which the opening of the shell can be closed when the animal is retracted. Fresh and salt water.

The number of species of *Cothurnia* has become so great that the difficulty in placing forms is almost sufficient to discourage the systematist; as Bütschli well remarks, the variations in the theca have been made the basis of new species so many times that the genus is almost as confused as *Difflugia* among the rhizopods or *Campanularia* among the hydroids. The length of cup, of stalk, the presence of annulations on stalk or cup, etc., have given rise to many specific names, the majority of which I believe can be discarded. According to such differentials the same branch of an alga holding a hundred specimens of *Cothurnia crystallina* yield 10 or 12 species, whereas they are merely growth stages of one and the same form.

Cothurnia crystallina Ehr. Fig. 62.

Synonyms: *Vaginicolla crystallina* Ehr., Perty, Eichwald; *V. grandis* Perty; *V. pedunculata* Eichwald; *Cothurnia crystallina* Claparède & Lachmann, D'Udek.; *C. gigantea* D'Udek; *C. maritima*, *C. crystallina* Cohn; *C. grandis* Meresch.

The form of the cup shows the greatest differences; sometimes it is cylindrical, sometimes elongate thimble-shape, sometimes pouch-shape, corrugated or smooth on the sides, and wavy or smooth on border. Frequently the basal part becomes stalk-like, but this is very short. When present, the stalk may or may not have a knob-like swelling. The animal within the cup may or may not be borne on a stalk, and this stalk may or may not be knobbed. The cups are colorless or brown. The animal is very contractile and may stretch half its length out of the cup or retract well into it. There is no operculum. The length of the cup varies from 70μ to 200μ (*C. gigantea; Vag. grandis*, etc.). From Entz.

There is nothing to add to Entz's characterization of this species, which is found both in fresh and salt water. The variability of the cup and stalk is quite noticeable in the Woods Hole forms.

FIG. 63.—*Cothurnia imberbis.*

FIG. 64.—*Cothurnia nodosa.*

Cothurnia imberbis Ehrenberg, var. **curvula** Entz. Fig. 63.

Synonyms: *C. imberbis* Kent et al.; *C. curvula* Entz; *C. socialis* Gruber?

The lorica is swollen posteriorly, narrowest at the oral margin, bent on its axis and is supported on a short stalk. It is perfectly smooth and without annulations. The animal itself has no definite stalk. When fully expanded the animal emerges but slightly from the margin of the cup. Fresh and salt water. On red algæ. Dimensions of Woods Hole form: Cup 50 to 55μ long; greatest diameter 22μ; length of stalk 4 to 5μ.

Cothurnia nodosa Claparède & Lachmann. Fig. 64.

A. Smooth cup.—*Cothurnia maritima* Ehr., Eichwald, Stein, Kent.
B. Cross-ringed cup.—*C. pupa* Eichwald, Stein, Cohn; *C. nodosa* Cl. & L.; *V. crystallina* Entz '78; *C. pontica* Meresch., Kent; *C. cohnii* and *pupa* Kent; *C. longipes* Kellicott '94.

The cup is elongated, swollen centrally, tapering at oral end and conical at base or rounded. Oral opening either circular or elliptical. Cross rings may or may not be present, and the cup is either smooth or annulate. Length of cup 70μ to 80μ. The stalk which supports the cup is extremely variable in length. The animal is borne upon a stalk of variable length within the cup.

Entz states that the many variations which this species exhibits run into each other so gradually that he does not believe it wise to separate them. The Woods Hole forms which I found on algæ of various kinds were nearly of a size, and did not vary much from the one figured. Kellicott '94 described a *Cothurnia* from Woods Hole under the name of *C. longipes*, which I believe is only a long-stemmed variety of *C. nodosa*. My form has the following dimensions: Cup 75μ; cup stalk 38μ; animal stalk 14μ.

Key to families of Suctoria.

a. Unattached forms; ventral cilia present; one suctorial tentacle ..... *Hypocomidæ*
b. Attached forms; thecate and athecate tentacles simple, one or two in number ..... *Urnulidæ*
c. Thecate; posterior end of cup drawn out into stalk; walls perforated for exit of tentacles ..... *Metacinetidæ*
d. Stalked or unstalked; globular; tentacles of different kinds, some knobbed, others pointed (2 genera **Ephelota* **Podophrya*) ..... *Podophryidæ*
e. Naked or thecate; stalked or not; tentacles numerous, usually knobbed and all alike ..... *Acinetidæ*
f. Naked; athecate; tentacles numerous, all alike, knobbed and grouped in tufts. They may be simple or branched ..... *Dendrosomidæ*
g. Sessile forms resting on basal surface or on a portion raised like a stalk; tentacles many; short and knobbed; distributed on apical surface or localized on branched arms ..... *Dendrocometidæ*
h. Stalked or sessile; tentacles long, rarely knobbed, supported on proboscis-like processes ..... *Ophryodendridæ*

Genus PODOPHRYA Ehr. '33.

(Bütschli '88; Stein '59; Perty '52; Cienkowsky '55; Quenn. '69; Hertwig '77; Maupas '81.)

The body is globular, with tentacles radiating in all directions. The tentacles may be very short or very long. The stalk also is either short or long, and some species form stalks but rarely (*P. libera*). The macronucleus is centrally placed and globular to ovoid in form. The contractile vacuole is usually single. Reproduction takes place by division; the distal half developing cilia and becoming a swarm-spore. Fresh and salt water.

Podophrya gracilis, n. sp. Fig. 65.

Of all the *Podophrya* that have been described not one approaches this minute form in the relative length of the stalk. The body is spherical and is covered with short capitate tentacles. The stalk is extremely slender, bent, and without obvious structure. There are one or two contractile vacuoles in the distal half of the body. The nucleus is small and is situated near the insertion-point of the stalk. Reproduction not observed. Diameter of body 8μ; length of stalk 40μ. Only one specimen seen.

Genus EPHELOTA Str. Wright '78.

(Bütschli '88; Ishikawa '96; Sand '98.)

Small to medium-sized and large forms; colorless to brown. The body is globular or oval or wedge-shape, sometimes quadrangular. The stalk is variable, sometimes 1 mm. in length. The diameter of the stalk increases from the point of attachment to the body of the animal; it is usually striated either longitudinally or transversely, or both. The tentacles are of two kinds and are usually confined to the anterior half of the body. Some are long and sharp-pointed and adapted for piercing; others are short, cylindrical, usually retracted and capitate, adapted for sucking. Contractile vacuoles vary from one to many. The macronucleus is nearly central in position and usually of horseshoe shape,

but is frequently branched and irregular. Reproduction is accomplished by external multiple budding, usually from the anterior half of the body. Salt water.

Ephelota coronata Str. Wright. Fig. 66.

Synonyms: *Hemiophrya gemmipara* S. K.; *Podophrya gemmipara* Hertwig.

The body is spheroidal, ovate, or pyriform, with numerous sharp-pointed tentacles and a few straight, uniform tentacles. The stalk is about three times the length of the body and tapers from its

FIG. 65.—*Podophrya gracilis.*

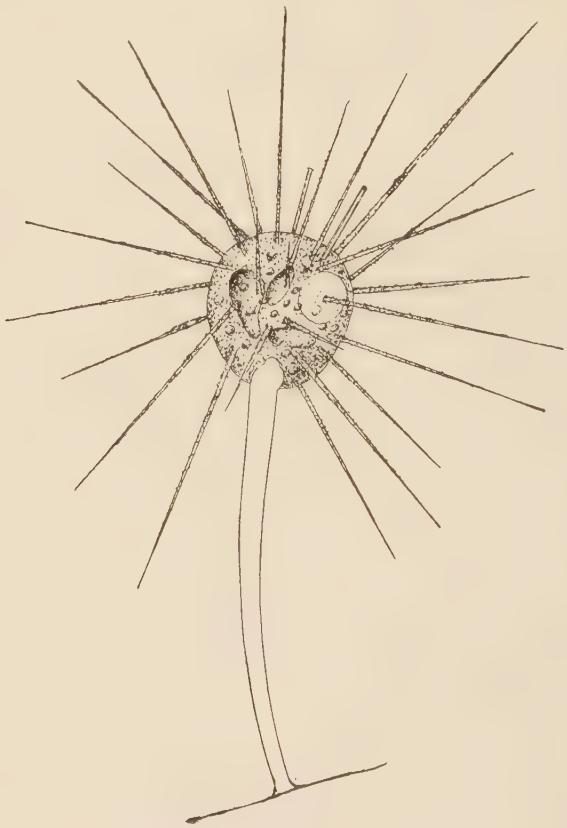


FIG. 66.—*Ephelota coronata.*

widest part at the insertion in the body to the narrowest part at the point of attachment. It may or may not be longitudinally striated. This is one of the commonest of the *Suctoria* found at Woods Hole. It is usually present on Campanularian hydroids, but may be found on algæ and Bryozoa.

Length of body 90μ to 200μ.

Genus ACINETA Ehr. '33, Bütschli '88.

(Stein '54, '59; Claparède & Lachman '58; Quennerstedt '67; Hertwig '76; Mereschowsky '79; Entz '84; Kent '81; Maupas '83; Gruber '84; Gourret & Roeser '86, and others.)

Small to medium-sized forms. The distinguishing feature is that the stalk is swollen at the distal extremity to form a cup or basin in which the animal rests. The cup may be developed until the body is nearly inclosed. The macronucleus is spherical or band form. The contractile vacuole is usually single. Budding, so far as known, is endogenous. Fresh and salt water.

Acineta divisa Fraipont '79. Fig. 67.

This extremely graceful form is common on Bryozoa at Woods Hole. The cup is shaped like a wine glass and is specifically characterized by a cup-formed membrane upon which the animal rests. The animal thus has the appearance of being suspended on the edge of the cup. The stalk is slender and about 4 times the length of the body. The tentacles are all capitate and distributed, and about $2\frac{1}{2}$ times the body length. They sway back and forth very slowly. The nucleus is spherical and central in position. The contractile vacuole lies near the periphery.

Length of body 27μ; of stalk 100μ; of extended tentacle 65μ.

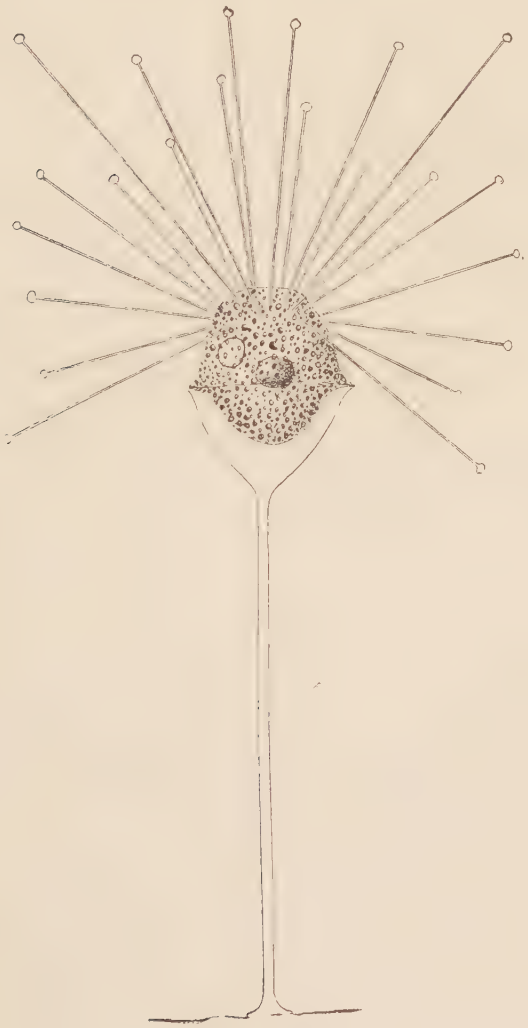


FIG. 67.—*Acineta divisa.*

Acineta tuberosa Ehr. Fig. 68.

Large forms of *Suctoria* with tentacles arranged in fascicles. The stalk is variable in length and the cup is frequently so delicate that it can barely be made out. A specific characteristic is the break in continuity of the cup at different points, and through these

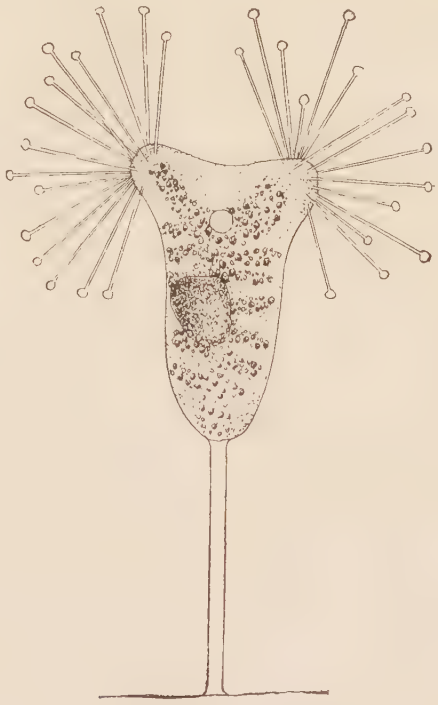


FIG. 68.—*Acineta tuberosa*

places the tentacles emerge in bundles. The tentacles are capitate and in the Woods Hole form, 15 in number in each of the two bundles. The endoplasm is granular and yellowish in color. The coloring matter is frequently arranged in patterns. The nucleus is spheroidal. The contractile vacuole is in the anterior third of the body about midway between the bundles of tentacles. Reproduction not observed.

Length of body 330μ.

Genus TRICHOPHRYA Clap. & Lach. '58.

(See Kent '81; Entz '84; Bütschli '88; Sand 1901.)

Small forms to medium size; no cups or stalks. The body is spherical to elongate, usually, however, more or less irregularly lobed and changeable. The tentacles are in fascicles which are usually borne upon lobed or swollen places. The body is always more or less spread out. Contractile vacuoles variable. The macronucleus is spherical, elongate, band-formed or horseshoe-shaped. Reproduction takes place by endogenous budding, and the swarm spores are flat or lenticular with a distinct ciliary girdle. They are frequently parasitic. Fresh and salt water.

Trichophrya salparum Entz '84.

Bütschli '88; Schewiakoff '93; *Trichophrya ascidiarum* Lachmann '59; René Sand 1901.

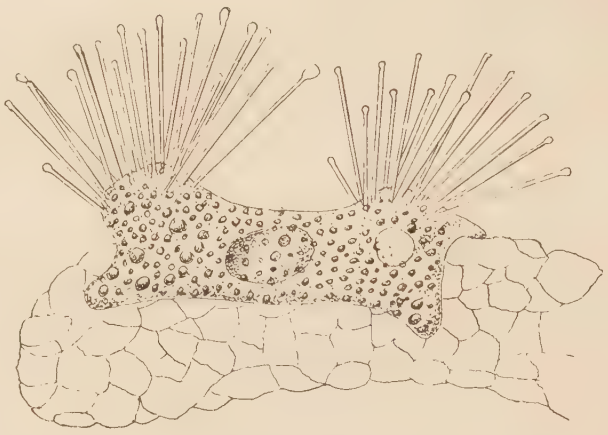


FIG. 69.—*Trichophrya salparum.*

The body is somewhat cup-form, with a large, flat base. The anterior border is rounded, each of the ends being somewhat truncate and carrying a bundle of tentacles all capitate and similar. These may be continued internally as far as the nucleus (Sand). The cytoplasm is uncolored, but may contain some brilliant granules. The nucleus is granular and spherical, band or horseshoe formed.

This species was found by Dr. G. Hunter on the branchial bars of the Ascidian *Molgula manhattensis*, where great numbers of them are often parasitic.

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